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A COMPARATIVE STUDY OF ELECTRICITY MARKET DEREGULATION IN CALIFORNIA AND FINLAND

Rahoituksen pro gradu-tutkielma
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ABSTRACT
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Objectives of the Study

The objective of the study is two-dimensional. First, the study aims at comparing the California and Finnish market deregulations to each other descriptively, based on pre-reform markets and their related inefficiencies. Second, the study aims at testing quantitatively the success of deregulation processes in both markets by examining the wholesale spot price behavior in the newly generated official exchanges in both markets. Special emphasis is again on the comparative analysis.

Research Methodology

The first empirical part of the study is totally qualitative, and the findings are thus presented and discussed descriptively and demonstrated with figures. The second empirical part of the study is based on numerical data, so it calls for quantitative statistical analysis. Particularly, market efficiency and welfare gains in California and Finnish post-reform markets are tested both in absolute and comparative sense. Various statistical tests are used for examining price volatility, autocorrelation, transmission constraints and trading efficiency to determine the level of overall efficiency. Welfare gains are examined graphically and by calculating nominal and real price movements.

Sources of the Study

Science literature and interviews with industry participants in California and Finland are used for conducting the qualitative analysis. Price and some additional related data from California markets are obtained from the University of California Energy Institute. Data from Finnish markets are obtained from EL-EX (Ville Pesonen), Helsingin Energia (Harri Mattila/Heli Vilkki), NORDEL and www.energia.fi.

Results

California electricity market reform was conducted heavy-handedly, partly due to the heavy structures and regulatory ties prevailing in the pre-reform markets. Finnish electricity market reform was conducted light-handedly, since the structures did not require heavy measures to achieve full liberalization. The evidence from the quantitative analysis shows that the Finnish markets appear more efficient than the California markets. Welfare level seems also higher in the Finnish post-reform markets than in the California markets, although producer welfare has not increased markedly and consumers have not gained welfare quite as expected in neither market.

Keywords

Electricity, Deregulation, California, Finland, Wholesale markets, Electricity prices

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VERTAILEVA TUTKIMUS KALIFORNIAN JA SUOMEN SÄHKÖMARKKINOIDEN VAPAUTTAMISESTA

Tutkimuksen tavoitteet

Tutkielmalla on kaksi päätavoitetta. Ensiksi, tutkimuksen tavoitteena on verrata Kalifornian ja Suomen sähkömarkkinoiden vapauttamistoimenpiteitä toisiinsa deskriptiivisesti, nojautuen vapauttamista edeltäneisiin markkinarakenteisiin ja tehottomuuksiin. Toiseksi, tutkimus pyrkii testaamaan kvantitatiivisesti vapauttamisprosessien onnistuneisuutta tutkimalla tukkumarkkinasähkön hintakehitystä uusissa sähköpörsseissä molemmilla markkinoilla. Kvantitatiivisen analyysin pääfokus on edelleen vertailevassa tutkimuksessa.

Metodologia

Tutkimuksen ensimmäinen empiirinen osa on täysin kvalitatiivinen, ja tulokset esitetään ja analysoidaan deskriptiivisesti ja graafisesti havainnollistaen. Toinen empiirinen osa perustuu täysin numeeriseen aineistoon ja sen pääpaino on kvantitatiivisella tilastollisella analyysilla. Markkinoiden tehokkutta ja vapauttamistoimenpiteiden hyvinvointivaikutuksia tutkitaan Kalifornian ja Suomen vapautuneilla sähkömarkkinoilla sekä absoluuttisesti että suhteessa vastaaviin tuloksiin toisilta markkinoilta. Useita tilastollisia testejä sovelletaan aineistoon, jotta volatiliteetin, autokorrelaation, siirtokapasiteettivajeen ja kaupankäynnin tehokkuuden vaikutukset markkinoiden yleiseen tehokkuuteen voitaisiin selvittää. Hyvinvointivaikutuksia testataan graafisesti ja laskien nominaalisia ja reaalisia hintamuutoksia.

Tutkimuksen lähteet

Soveltuvia tieteenalan teoksia sekä asiantuntijahaastatteluja Kaliforniassa ja Suomessa on käytetty kvalitatiivisen analyysin laatimiseen. Hinta- ja täydentävä aineisto Kalifornian markkinoilta on saatu Kalifornian yliopiston energia-instituutista. Suomen markkinoiden aineisto on saatu EL-EX:istä (Ville Pesonen), Helsingin Energiasta (Harri Mattila/Heli Vilkki), NORDEL:sta ja www.energia.fi-sivuilta.

Tulokset

Kalifornian sähkömarkkinat vapautettiin 'vahvakätisesti', osaksi johtuen markkinoilla vallitsevista vahvoista rakenteista ja sidoksista. Suomen sähkömarkkinoiden vapauttaminen tapahtui 'kevytkätisesti', koska rakennemuutos ei vaatinut vahvoja toimenpiteitä saavuttaakseen täyden vapauttamisen. Tulokset osoittavat, että Suomen sähkömarkkinat ovat tehokkaammat kuin Kalifornian sähkömarkkinat. Hyvinvointitaso on myös korkeampi Suomen sähkömarkkinoilla vapauttamisen jälkeen, kuin Kalifornian markkinoilla, vaikka tuottajien hyvinvointi ei ole noussut huomattavasti eikä kuluttajat ole saaneet hyvinvointia odotusten mukaisesti kummillakaan markkinoilla.

Avainsanat

Sähkö, Vapauttaminen, Deregulaatio, Kalifornia, Suomi, Tukkumarkkinat, Sähkön hinta

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1 INTRODUCTION

What should occur under a sensible policy of deregulation is unclear.
The optimistic view is that once the changes start, the process will lead inevitably to full deregulation – the experience in transportation reform.
The pessimistic view is that the regulator's reluctance will severely hinder evolution and overextended battles will prevail – the telephone case.
(Gordon, 2001; 351-352)

The case of electric power seems to be the most recent experiment in the deregulation era, and its pathway to the world of free market has not been a clear-cut success. Still, electricity deregulation does not clearly fall into either category of success – transportation or telephone – it is totally a story of its own. Consequently, the case of electricity deserves a closer look.

1.1 Background

Deregulation, liberalization, restructuring, policy reform, even re-regulation – all can bear the same meaning – a process of capturing the advantages of free market economy by abolishing regulations set to govern industries vital to the public welfare. However, the process of replacing regulation with market competition can take many forms, structures and variations with different implications for the welfare level. Even though the reforms vary from each other, all of them share the same goals. Namely, the overriding aim is to create more efficient and transparent markets with competition bringing the benefits of free entry and wider variety of choices and innovations, which ultimately boost the economy through increased supplier and consumer surpluses.

The reforms in power sector like those in other network industries have arisen primarily because two fundamental ideas have been challenged during the last two decades: the belief that electricity industry is governed by natural monopolies and the idea that the generation, transmission and distribution of electricity are pure technical issues handled by engineers (Moorhouse, 2000; 2). As a consequence, the idea of economists promoting alternative market regimes based on independent suppliers and consumers facing the same market-derived demand and supply curves emerged. These were the same economists who manifested the significant gains accruing from supporting competition in power markets.

The main functions in electricity industry are generation, transmission (high voltage networks), system control, distribution (medium and low voltage networks) and sales of electricity (wholesale and retail sales) - all of which have traditionally been organized as a vertically integrated monopoly (Sulamaa, 2001; 5). Electricity pricing in pre-reform markets was based on long-term contracts between producers and utilities. Deregulation totally changed the pricing practices, as the new official wholesale power exchanges with continuous trading emerged. However, price formation in these pools differs quite markedly from e.g. pricing of stocks and thus deserves extra attention. Therefore, pricing issues are discussed fairly extensively in chapter 4.

The tight regulation of electricity supply industry in pre-reform markets was justified and viewed necessary due to various reasons: the existence of natural monopoly conditions due to high sunk costs involved in generation, significant externalities and public good characteristics[1] involved, and the fact that electricity is considered a basic service crucial for social welfare. These issues have traditionally been managed and controlled either by direct regulation or state ownership control in electric utilities.

Despite the market economists, political groups and other free market activists pressing the reforms, the deregulation proposals in the U.S. seemed unlikely when first introduced. The strongest opposition in California came from various interest groups with strong influence in the regulatory process, which benefited greatly from the status quo. Evidently, the incumbent utilities with high costs and regulated level profits stood to lose the most and were the most reluctant to cooperate. Even so, the political obstacles were overcome in the U.S. by introducing compensatory measures for the "breach of the regulatory contact". In contrary, the power market reform raised only little political controversy in Finland, since it was introduced and implemented by both Conservative and Democratic governments (Midttun, 2000). This outcome distinctly reflected the common characteristic of social democracy prevailing in all Nordic power markets.

[1] Externality arises when one individual's consumption "spills over" to other individuals and thus imposes costs or benefits on others. Public good, on the other hand, is something in which one individual's consumption does not exclude consumption by others. However, in either case under competition, public goods or goods with externalities can be either over- or underproduced relative to consumer demands because all the relevant costs and benefits are not embodied in the prices of goods (Klein and Sapper, 2001).

A new market orientation brought by deregulatory process means a 180 degree turn for several interest groups - away from secured profits and markets with entry barriers to a regime with open access to more participants and profit redistribution. To understand the characteristics of the particular deregulatory model chosen for specific markets and its implications for the economy and society, it is necessary to reflect the reform to the market structure prevailing before the change took place. It is clear that markets with more stringent regulations need more "heavy-handed" deregulatory processes, whereas more market oriented structures can be restructured with "lighter-handed" reforms. California represents the heavier governance market in which privately owned utilities used to be strictly regulated by both state and federal regulatory agencies. Nevertheless, the Public Utility Regulatory Policies Act (PURPA) of 1978 helped to set the stage for heavy reforms of the late 1990s. Conversely, in Finland, where the regulation was mostly implicit, the Electricity Market Act of 1995 never resulted in dramatic structural and regulatory changes.

1.2 Objectives of the Study

The overall objective of the study is to compare the electricity market reforms in Finland and California, reflect them and their special characteristics to each other and to identify and analyse their implications for the post-reform markets. In effect, the study has a *two-dimensional approach* to the topic – it encompasses a comparative, qualitative empirical analysis of the power market deregulations in California and Finland as well as a quantitative empirical analysis of the success of those deregulations, using power wholesale prices as an aggregate indicator. The main emphasis remains on the qualitative analysis. An economic, rather than technical perspective is emphasized in the analysis of the market reforms, with theories and models taken from finance, micro-, macroeconomics and statistics.

The history of the power industry, political views and legal issues influence strongly the choice of the reform model chosen. Therefore, the study aims at understanding why specific deregulation models were taken, how they tend to influence the degree and comprehensiveness of the reform and what is the distribution of roles, profits and welfare gains, given the old market model. Therefore, instead of concentrating only to the reforms per se, the problem is approached through examination of the pre-reform choices and structures. This approach is meaningful when analyzing the specific areas of diversity in the deregulation models and the motivation behind specific market design choices.

Wholesale electricity markets probably changed the most in the course of deregulation. Particularly, deregulation processes in both California and Finland created a whole new venue for trading electricity – the official, organized electricity exchange. The idea was to withdraw from the pre-reform practice of trading wholesale power with long-term contracts to trading it collectively in official pools with transparent, market-based price formation. Due to the primary role of wholesale markets in deregulation, the quantitative part of the study aims at measuring the success of deregulation by examining wholesale prices.

The study emphasizes an economic perspective in analyzing the wholesale power markets and, as such, begins the wholesale price analysis with a profound theoretical assessment of the fundamentals of the deregulated electricity markets and electricity price formation. The quantitative empirical part of the study aims at measuring and comparing the success of the reforms in California and Finland in statistical terms. In particular, the analysis is conducted by analysing wholesale spot electricity prices, both in absolute and relative terms, and by assessing their implications for the efficiency and welfare gains of the respective markets. This part of the study aims at providing more depth and robustness to the study, and giving an empirical framework for further analysis and discussion.

The final objective of the study is to provide specifications of "good" and "bad" deregulatory choices made in the two markets for reformers in other jurisdictions to benchmark. This benchmark demonstration is conducted by analyzing the diverse deregulatory models chosen in two distinct markets and the consequences of those reforms, from the perspective of a reformer. Thus, the study aims not only to be a backward-oriented ex post research paper, but rather a forward-looking portrayal of possible consequences of regulatory actions possible in the future, as well.

1.3 Research Questions

A comparative market reform analysis like this study most naturally starts by analysing the status quo – the base-markets, which have been challenged when the impetuses for reforms were initiated. The pre-reform market ultimately sets the framework for the specific deregulation model chosen and, therefore, these markets are first analysed and the questions about their implications for the specific liberalization structure are discussed. Specifically, the questions about the inefficiencies of the pre-reform markets are addressed. The study continues by questioning the objectives and goals of the deregulation process in general and, more specifically, stressing the differences in ambitions of the reforms in respective markets.

Further, based on the status quo-markets and their respective sets of goals, two distinctive deregulatory models are drawn. The markets are then reflected to each other by stating various questions, elementary to the chosen structures. Finally, a question about the success of the deregulation is addressed by assessing the outcomes of the reform processes. The two universally recognized objectives – welfare gains and efficiency - are considered when analysing and comparing wholesale price movements in the open, newly generated power trading markets of California and Finland.

At the end, the following question should have a justified and robust answer:

What are the economic foundations for the deregulatory processes chosen, the reforms' explicit features and the respective monetary outcomes in terms of efficiency and welfare gains?

Figure 1 summarizes the research questions of the study.

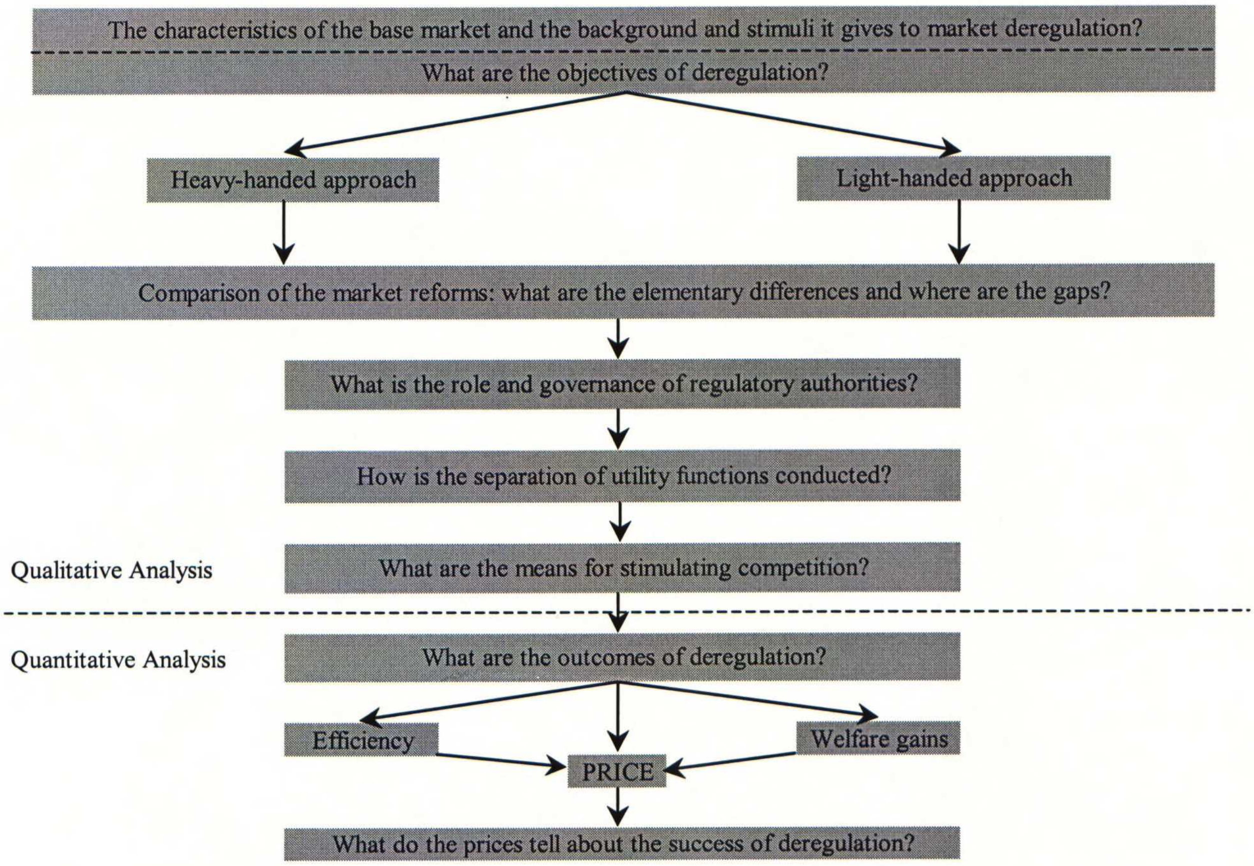

Figure 1 Research questions of the study.

1.4 Structure of the Study

The study is structured as follows. The second chapter discusses the pre-reform markets in California and Finland, in terms of organization, governance structure as well as general practices and policies. The subject is approached from economic perspective rather than taking a simple descriptive orientation. Hence, specific industry details and market statistics are intentionally left out of the discussion. Moreover, the chapter discusses the market imperfections, which ultimately gave the impetuses for reforms. The inefficiencies of the markets are also reflected to the characteristics and choices made in the pre-reform markets. The third chapter discusses the deregulatory models chosen in California and Finland and compares them to each other. As a consequence of the specific deregulatory models taken, different outcomes occur. The outcomes of success/failure are discussed quantitatively in chapter six.

The fourth chapter introduces the theoretical framework of wholesale electricity spot markets and the price formation in those markets. Specifically, the critical issues of market efficiency, price volatility and welfare gains are discussed in more detail. The fifth chapter discusses the conduction of the quantitative empirical study. Particularly, the chapter first outlines the fundamentals of the wholesale market mechanisms in California and Finnish power markets, then introduces some related previous findings in the literature of electricity markets and presents the sample data. Also, the research hypotheses are stated and the used methodology shortly presented. The sixth chapter introduces the results of the quantitative analysis. Descriptive statistics of the data is first discussed, which is followed by the test results of the analysis. Also, a short summary of results is provided. The seventh chapter concludes the study by summarizing the findings and discussing the implications of the reforms and the results of this study. Finally, the current stages and future scenarios of the California and Finnish electricity markets are weighed and the possibilities for further research suggested.

2 THE OLD STRUCTURE AND IMPETUS FOR REFORMS IN CALIFORNIA AND FINLAND

An institutional structure in a given point of time reflects not only the current configurations but usually consists of "archeological layers" of institutional principles and logic of actions that reflect the context and time of origin of different institutions. Thus, the market reforms effectively become a new layer on top of other layers that are still partly active (Olsen, 1992). From this reason, deregulation process cannot be meaningfully analysed in isolation from the pre-reform institutional structures still laying down some of the rules of the game.

2.1 Pre-Reform Markets

Because of the special commodity characteristics of electricity and the necessary grid operations involved, the electricity industry has traditionally consisted of state-regulated, vertically integrated natural monopolies serving their respective franchise areas under specific return and entry regulations

(VanDoren, 1998). This system of regulation was supposed to accomplish mainly two things: to enable utility to raise finance for investment at an acceptable cost, using the guaranteed rate of return on capital as a collateral, and to prevent the utility from exercising market power by charging excessive monopoly rents.

The pre-reform electric power systems were constructed from *engineer's perspective*, rather than *economist's perspective*, in a sense that the organization was technically feasible but not allowed to react to market forces. Thus, electric systems around the world used to be physically and operationally very similar: varying degrees of regulation was always involved but the state played an integral role in the governance of the industry and natural monopolies operated in every system function[2]. In effect, the market resembled a *macro-oriented* planned economy model, in which a neoclassical theory of a firm operating as a monopoly and management accounting approach (rather than market supply and demand mechanisms) in setting the rates were the core principles of the framework.

The structure of Finnish markets has been unique and, on some occasions, at odds with other countries. The California markets, on the other hand has been a good example of a classical structure with high government involvement and strict regulation governing the whole vertical value chain. Next, some special aspects of the respective pre-reform markets are discussed.

2.1.1 Direct Dual-Level Regulation in California

The electricity industry structure in California before restructuring followed almost literally the basic definition of a regulated monopoly industry structure: it encompassed state-regulated, vertically integrated monopolies, which generated, transmitted and distributed electricity within their specific franchise areas subject to traditional rate-of-return regulation by the state regulatory commission. These companies built their own generating plants and coordinated the planning of generation with the planning of transmission through their own lines. Consequently, the utility customers received a

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[2] According to a textbook definition, a given production technology is said to exhibit the property of *natural monopoly* if a single firm can supply the market at lower cost than can two or more firms (Carlton and Perloff, 1994). The natural monopoly technology provided impetus for regulation, because the discipline of market was not seen as sufficient enough to tame the negative consequences of excessive monopoly power. Regulation would increase consumer welfare only if the cost savings of monopoly in transmission network would outweigh the costs of administrative controls.

bill, which had all these functions "bundled" into a single tariff (Hunt, 2002; 12). These regulated retail electricity prices comprised the following cost components:

$$P_R = C_T + C_D + C_G + C_R + DSM \qquad (1)$$

where P_R equals total regulated (bundled) price of retail service[3], C_T and C_D denote the average total accounting cost of transmission and distribution services, respectively, C_G equals average total accounting cost of owned generation and power contracts including contracts with independent power producers, C_R equals average cost of customer services and *DSM* denotes cost of various public benefit programs (Joskow, 2000; 177).

The philosophy of power pricing, according to Averch and Johnson (1962), in California pre-reform markets is illustrated in Figure 2, where D represents market aggregate demand, MC equals marginal costs of generation and AC equals average costs of generation.

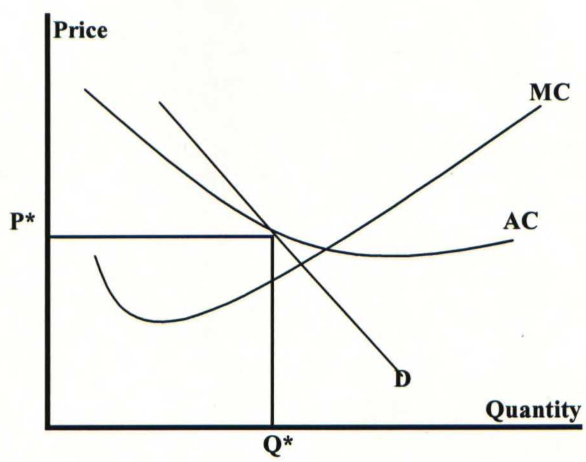

Figure 2 **A rate setting mechanism of a regulated monopoly in California pre-reform markets (Averch and Johnson, 1962).**

[3] According to the data provided by Energy Information Administration, retail rates of residential customers in California averaged $11.50 and $10.60 in 1997 and 1998, respectively (country averages $8.43 and $8.26). The figures for same rates of industrial customers totaled $6.95 and $6.59 (country averages $4.53 and $4.48). The competitive disadvantage brought by the higher rates in California in relation to the neighbouring states was one of the reasons California initiated its deregulatory reforms in 1996.

Several special characteristics of power industry and monopoly structure support the model in Figure 2. First, due to the voluminous investments in network and generating capacity with rather low marginal costs in low quantities[4], average costs are declining as volume increases. Thus, economies of scale result in marginal costs being lower than average costs over a relevant range of output (Carlton and Perloff, 1994). Second, monopoly regulation sets the price at higher level (P* with quantity Q*) than could be charged in competitive markets (the point where MC and D intersects), which is still lower than unregulated monopoly could charge with monopoly rents. Finally, this administered price P* is determined on full-cost or rather on average-cost basis because it allows a fair return on invested capital, while yet serves the overall interests of the society in protecting buyers from too high a price, recapturing the loss in consumer surplus associated in monopoly price, promoting stability and preventing collusion (Sharkey, 1982).

The California pre-reform electricity market was concentrated around three investor owned utilities, IOUs, (Pacific Gas and Electric, PG&E, serving the Bay Area and the northern parts of the state; Southern California Edison, SCE, serving the Middle- and South-California; and San Diego Gas and Electric, SDG&E), operating as monopolies in their regional franchise areas, and accounting for two thirds of the state's total electric service. The remainder of production was supplied by municipal utilities, public water agencies and irrigation districts. Since California belongs to a shared power transmission network (Western System Coordinating Council, WSCC) with ten other states and parts of Mexico and Canada, the utilities purchased substantial amounts of power from other states in the network, which (including the wholesale transactions and transmission) was regulated by the Federal Energy Regulatory Commission (FERC). In-state generation, transmission and distribution, along with the retail tariffs, were regulated by the California Public Utilities Commission (CPUC) (Moore and Kiesling, 2001).

One of the special characteristics in the pre-reform California electricity markets was a depressed level of investments in new power plants. This was a result of the utilities' low economic incentives to invest, due to tight environmental legislation, strict state laws forbidding new nuclear power plant construction and regulatory uncertainties (Varian, 2001). Other important characteristics were, and

[4] The theory and practice tells that when production volume increases over a certain level, the marginal costs often start increasing, because less efficient production facilities and methods with lower capacities (and higher marginal costs) have to start operating.

still are, extensive use of natural gas in power production and fairly high level of imported power (varying from 15% to 20%). Figure 3 depicts the power procurement mix in California in 2001. The most notable change from pre-reform markets has been a slightly lower level of renewable power and increased use of natural gas. Namely, from late 1990s through 2002, the most types of power plant applications filed were natural gas-fired combined cycle, simple cycle and cogeneration power plants (CEC, 2001).

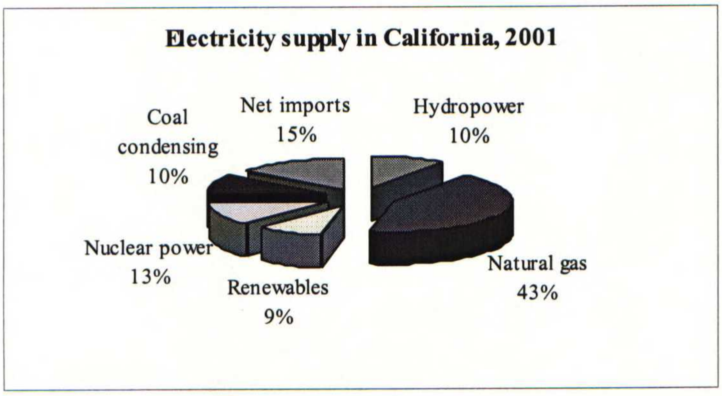

Figure 3 **Electricity supply in California by production type (California Energy Commission).**

The first element of governmental restructuring in the U.S. was the passing of the Public Utility Holding Company Act (PUHCA) of 1935. The implementation of the PUHCA clearly demonstrated the defects of such restructuring. In particular, the PUHCA required a massive effort to restructure U.S. public utilities by ordering change in the holding company approach and controlling future changes but turned out to be another innovation, which never worked well (Gordon, 1992; 337). Along with the PUHCA, a law creating federal public utility regulation of wholesale dealing in electricity was passed. The FERC was given a wide authority over the whole power system in the U.S. It works like an umbrella organization in a sense that it has the overall authority to regulate tariffs and profits, set certain rate calculation mechanisms and forbid all elements of price discrimination (according to the Federal Power Act), while the lower level oversight remains at state level. The FERC's authority to govern wholesale markets and trade between states as well as permitting imports and exports has made it a significant actor in the competitive development of the U.S. power markets.

2.1.2 Informal Club-Regulation in Finland

The electric industry in Finland has historically been under a mixed public and private ownership, with 40% owned by the private sector, 40% by the state and 20% by municipalities (year 1993 figures). The largest generator, Imatran Voima (IVO), subsequently merged with Neste Oy to form Fortum Oyj, was and still is with its 40% share the largest generator. In pre-reform markets, IVO also owned most of the central transmission grid (80%). The distribution sector is dominated by municipality owned utilities and comprises approximately 130 utilities.

The core elements of the Finnish market, as well as other Nordic power markets have historically been *self-regulation* and *cooperation and negotiation* in coordination of electricity supply (Newbery, 1995). According to Hjalmarsson (1993), adding the elements of *price leadership* and *yardstick competition*, the pre-reform markets were in effect controlled by *club-regulation*.

The Finnish electricity industry is modern, diversified, innovative and efficient production and distribution technologies are extensively used[5]. Also, cooperation and trade with other Nordic countries has been of importance for decades through a NORDEL consortium. Figure 4 shows the portfolio of electric power procurement in Finland. The figure represents a current situation (2000) but the composition of supply was almost the same in pre-reform markets - the only difference being today's higher level of CHP, which has come at the expense of lower level of hydropower production. The high level of CHP introduces one of the unique features of the Finnish electricity markets – the two-product horizontally integrated monopoly characteristic of Finnish utilities. Namely, a lot of utilities in Finland take care of local district heating in addition to serving electricity. This makes it harder for them to allocate common costs to produced units while easier to use various price discrimination practices (Kahn, 1970)[6].

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[5] Finland is also internationally well known for its efficient (efficiency ratios 85-90%) wood combustion technologies along with other CHP (Combined Heat and Power) technologies (Haljala, 2002). The use of CHP has been steadily increasing in the 1990s, accounting for 37% of total generation in 2000. The main fuel sources used in CHP are hard coal, wood, natural gas, peat and oil (Statistics Finland).

[6] Joint production is one of the prevalent elements of monopoly structure and is often hypothesized to bring economies of scope. Specifically, Rännäri (1992) researched the Finnish pre-reform markets and concluded that such economies exist due to combined production and delivery of electricity and heating.

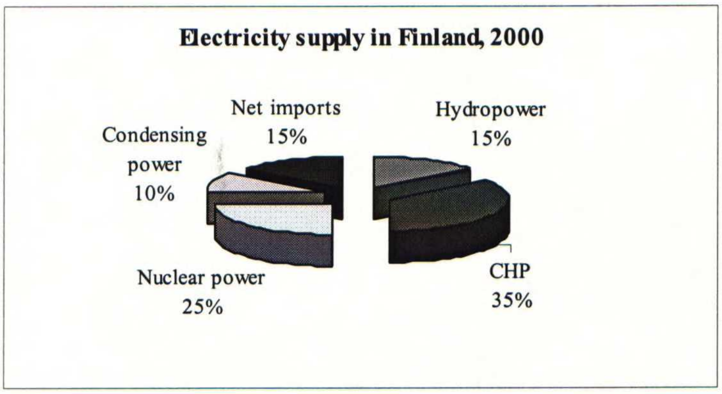

Figure 4 **Electricity supply in Finland by production type (Statistics Finland, 2000).**

Even before deregulation, multiple players operated in the Finnish electricity markets. In addition to the dominant generator, state-owned Imatran Voima (IVO) (accounting for 37% of total generation), industries (20%) and distribution companies (18% of total capacity) were important in power generation (Sähkölaitostilasto, 1994). The remaining 25% was produced by utilities of the TVS-group (Teollisuuden voimansiirto) - a group owned by Finnish forest and chemistry industries and the PVO (Pohjolan voima). In effect, two distinct groups possessed the wholesale power generation in Finland: the state-owned IVO-group and the industry-owned group clustered around PVO, TVO (Teollisuuden voima) and other energy-intensive industry producers. The wholesale power sold by the TVS-group was either industry surplus power or power produced by the group utilities and delivered to the owner companies (Lehto, 1995).

Cross-ownership made the structure of Finnish power generation fairly complicated. PVO and industries mutually owned the TVS-group, PVO and IVO shared the majority ownership in TVO and PVO was almost exclusively owned by industries. Figure 5 illustrates the structures and ownership ties in Finnish pre-reform markets.

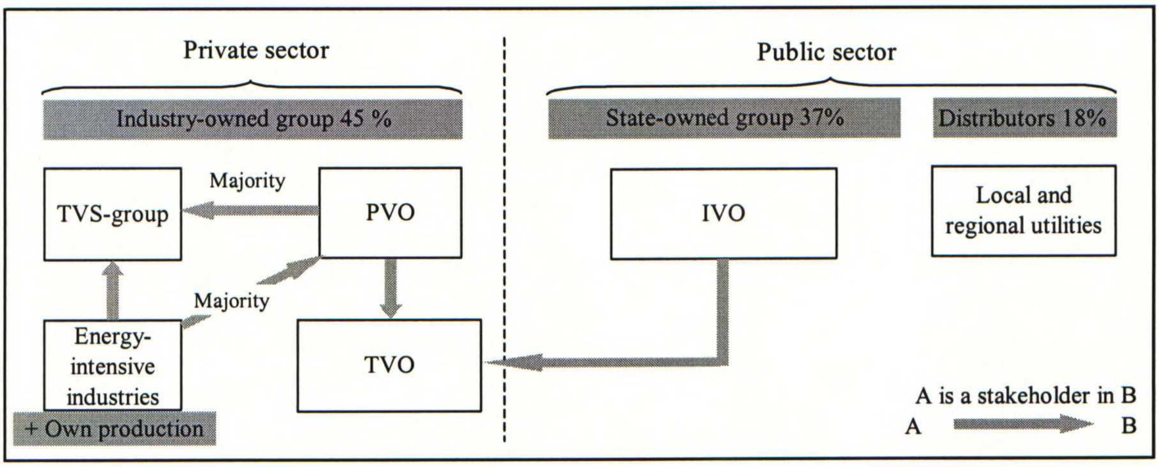

Figure 5 **Structure and ownership ties in Finnish pre-reform electricity generation function.**

The pre-reform Finnish electricity market structure was unique when compared to other markets in a global scope. Namely, numerous municipally owned distribution utilities with exclusive rights in predetermined geographical areas dominated retail sales, whereas IVO governed the wholesale level due to its majority ownership in national transmission grid (Niskanen, 1993). To be specific, a *duopoly* governed the national grid with exclusive rights, since its operation and ownership was divided between IVO and PVO – IVO's subsidiary IVS and TVS managing the transmission activities. Thus, the grid was not controlled by any single monopoly but instead by two distinct entities with different priorities and pricing practices. While both of the companies prioritized and optimized the generation of the facilities of the own group, they followed different wholesale and transmission policies – PVO served the special interests of its industry stakeholders and IVO strived to attain its dominant position through those policies.

"The Finnish club" was fairly large and involved 60 companies, all producers of at least 2 MW. The short-term coordination was based on a club contract (STYV-84, Sähköntuottajien yhteistyövaliokunta-84), which regulated e.g. the rules for frequency and voltage regulation and the coordination of annual power plant maintenance (Hjalmarsson, 1993). The market was in theory open but in practice dominated by IVO and limited by the long-term contracts and the difficult access to the grid. Small private pools operated under the "club" to dispatch in an efficient merit order, under the leadership of IVO and other producers (Pineau and Hämäläinen, 2000). Due to the dominant position of IVO, the wholesale price was a function of how IVO stressed profit maximization in relation to the social welfare. As IVO was a 100% state-owned company, it had to compromise its monopoly rents at least to some extent to serve the public interests. Thereby, the pricing in Finnish electric power markets was called "social pricing" in literature (Rännäri, 1998). Consequently, no explicit regulatory board was needed since the reliability of the system was ensured by the discipline of cooperation, public interests and self-regulation.

The power industry is regulated by the Electricity Act (Sähkölaki) of 1980, which licenses the utility operations and orders the Ministry of Trade and Industry to grant the operation permit (15 to 40 years) only if the utility meets certain operational, organizational technical and economical qualifications (Sähkölaki 2. luku 12§)[7]. In pre-reform markets the Ministry of Trade and Industry acted as the only regulatory organization. In addition to licensing plant construction, its main responsibilities included monitoring imports and giving judgments in case of a complaint on transmission prices and abuse of monopoly power in distribution. The monitoring of the Ministry was thus mainly reactive and relied on cooperation of players (Pineau and Hämäläinen, 2000).

Although the Competition Law (481/92 - Kilpailunrajoituslaki) forbids the abuse of market power and discriminatory trade and pricing practices, no explicit market rules were set on wholesale transactions and prices in the pre-reform markets. However, restrictions on transmission and distribution prevented competition in distribution level and the independent power producers were limited to trade only with regional distribution utilities, which could freely set the price and terms as they pleased. This use of market power obviously limited the entry of new producers (Niskanen, 1993). Another kind of market power existed, also. Namely, the dominant owner of the central power grid, IVO, could easily affect the operation of the distribution utilities by doing business in the areas where there were no independent power producers operating. The power prices were often determined by benchmarking the wholesale tariffs of IVO[8]. Most of the Finnish utilities had a tariff structure comprising general, time-of-day and demand tariff elements[9] (Rännäri, 1992).

[7] After law alterations of 1989 only facilities with nominal capacities greater than 250 MW needed a construction permit. Construction of nuclear or hydropower plants as well as power exports and imports have their own regulations.
[8] A good example of IVO's contracts and their pricing is IVO93-conracts, which encompassed long-term and short-term core components supplemented by capacity increasing- and decreasing-options and extension options for short-term contract parts. These elements effectively increased flexibility and reduced price risks. In pricing the contracts, time-of-day and demand elements were taken into account and the prices were tied to various indices such as wholesale price, living expense, wage, and coal price indices published by Statistics Finland (Kärkkäinen and Rajala, 1999).
[9] The last two had some price discrimination elements. Also, declining-block rate schedules were used in wholesale trades.

2.1.3 Summary

The pre-reform markets in California and Finland were both dominated by a certain level of monopoly or duopoly power and vertical integration was the base structure of those companies. Traditional to regulated power markets, neither California nor Finland allowed the prices to be determined according to market demand and supply, but used arbitrary pricing methods and formulas, instead. Additionally, both markets had some level of regulation or best practices and general policies, which the market actors followed. However, the markets had several distinctions in terms of market organization, level of regulation, powers enjoyed by the monopolies and pricing practices. Figure 6 illustrates the main characteristics of California and Finland in these "engineered markets".

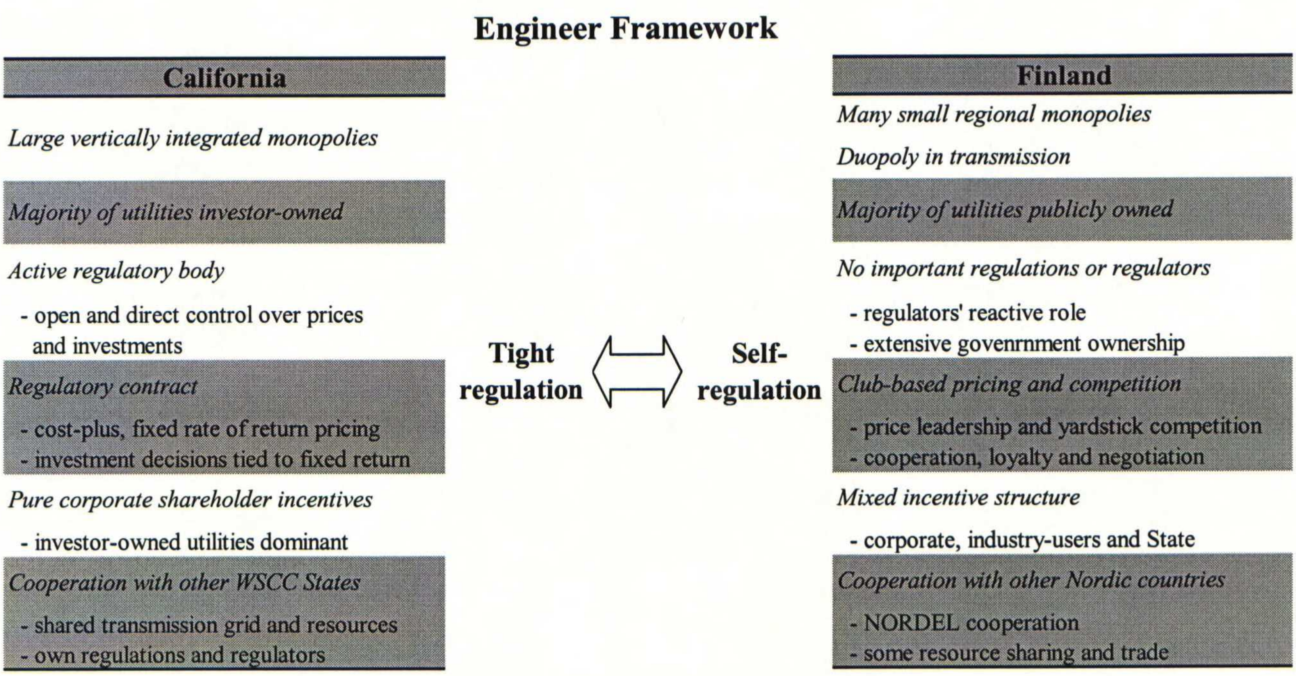

Figure 6 **Pre-reform markets in California and Finland based on the "Engineer Framework".**

2.2 Competitive and Economic Pressures Challenging the Old Structures

In theory and practice, three basic reasons exist for objecting the utility regulation to an industry. The first objection is that the industry never was a natural monopoly. The second alternative argues that the natural monopoly has disappeared due to the growth of the market. The third response is that whichever the circumstances, regulation is more likely to worsen than to improve the situation

(Gordon, 2001; 328). It is often stated that at least the generating portion of the electricity system is not monopolistic and thus can safely be deregulated. Conversely, transmission and distribution are monopolies, but regulating them is only appropriate if the natural monopoly is inefficient[10] and the government has the tools to correct that inefficiency. The natural monopoly is lost, if competition compels the company to set the price equal to the marginal production cost, which can happen when scale economies in vertical structure no longer exist[11]. Posner (1969) manifests the negative consequences of regulation and stresses the problems of killing the incentives to become more efficient and innovative when profits are limited and rents allocated *arbitrarily*. Also, Nozick (1974) argues that the limited knowledge of regulators implies that they cannot possibly know the difference from what would have been charged without regulation and what the regulated rates would produce.

The potential for industry reform will vary from country to country – depending on whether the system is government owned, investor owned or under a mixed ownership (Newbery, 1995). The main problems with the pre-reform regulated structures of both California and Finland were the negative effects of monopolies, but some of the problems deriving from inefficiencies were strongly related to the different ownership and governance structures of the respective markets.

2.2.1 The Case of California

The California pre-reform market structure had several weaknesses, which led to inefficient allocation of resources, welfare losses and huge stranded costs, all of which eventually contributed to deregulation per se and the specifics of the deregulation model chosen.

First, due to the rate determination on a cost-of-service basis, with a fixed rate of return percentage on invested capital, the utilities were induced to boost profits through increased, often economically unprofitable, investments (Averch and Johnson, 1962). Further, since the regulated rate of return did not factor in efficiency or profitability improvements and the utilities were immune to outside competition, the utilities lacked normal economic incentives to perform better and invest in new

[10] According to economic theory, natural monopoly is inefficient if it poses barriers of entry to the market and employs price discrimination.
[11] For more on scale economics in electric power generation, see e.g. Atkinson, S. and Halvorsen, R. (1984) and Christensen, L and Greene, W. (1976).

technologies. Indeed, the state enterprises and regulated monopolies did not aim at being innovative, since the regulated rates did not provide sufficient rewards on risky R&D investments. In California, these factors led to old, badly maintained and inefficient production and distribution fleet. Notwithstanding, the utilities received funding, because the prices were adjusted each year to keep the rates-of-return roughly constant and, consequently, investments were subject to little risk - particularly the market-related risk investors worry about (Alexander and Irwin, 1996). Therefore, under such regulation, conventional economic theory of rewarding sound decisions and practices did not apply but the utilities received the flat rate despite making imprudent investments.

Second, the issue of stranded costs arose when the rate regulation was contradicted[12]. Stranded costs are expenditures incurred during regulation period that firms cannot recoup in the presence of competitive entry (Baumol and Sidak, 1995). So, when opening regulated markets to competition, lower prices in the competitive markets will not cover the costs of pre-reform mandatory purchases of electricity and the shareholders of the utilities will suffer the loss equal to this difference. Therefore, stranded costs can be denoted Δ and quantified

$$\Delta = (R_1^e - C_1^e) - (R_2^e - C_2^e) \tag{2}$$

where R_1^e and C_1^e represent expected revenues and costs under regulation and R_2^e and C_2^e represent expected revenues and costs under competition (Sidak and Spulber, 1998; 184). In pre-reform markets, a *regulatory contract* between the CPUC and the utilities ensured the benefits of regulation to the utility – the fixed rates of return, entry barriers and exclusive franchise service area – and mitigated risks of making large irreversible investments. These contracts were also supposed to favor customers and shareholders by lowering costs of service brought about efficient levels of investment and borrowing costs due to the honoring contract commitments to the investors (See e.g. Spulber, 1989, and Joskow and Schmalensee, 1986). In practice, however, profits were often manipulated by excessive investments and investors' required rate of return did not sufficiently reflect the threat of breach of the regulatory contract, as efficient markets would imply.

[12] In California, stranded costs were estimated to be about $25 Billion, more than twice the equity investment in the companies' books. The costs were roughly equally devided between nuclear power plant investments and "Qualifying Facilities"-contracts (the contracts under the PURPA of 1978) (Joskow, 2000; 138).

Third, customers were not allowed to respond to fluctuating electricity prices, which lowered the price elasticity of demand close to zero. Services such as tailored demand side management or priority service[13] options did not exist because they economized on capital capacity of state monopolies and return earned by regulated utilities. Namely, such services had a potential of reducing the size, budget and employment level of the state monopoly and the accounting profits regulated utilities earned on capital on a cost-plus basis (Moorhouse, 2000).

Finally, the pre-reform regulatory framework in California power markets was problematic in a sense that the regulation was split between two levels - the federal government and the state – in a way that was established in 1935, when the industry was mainly a local industry. Thus, this fragmented structure resulted in markets with incompatible initiatives and lower efficiency, in which no one had overall authority to decide what needs to be done (Hunt, 2002).

Figure 7 illustrates the pre-reform electricity market structure in California and the efficiency pressures involved.

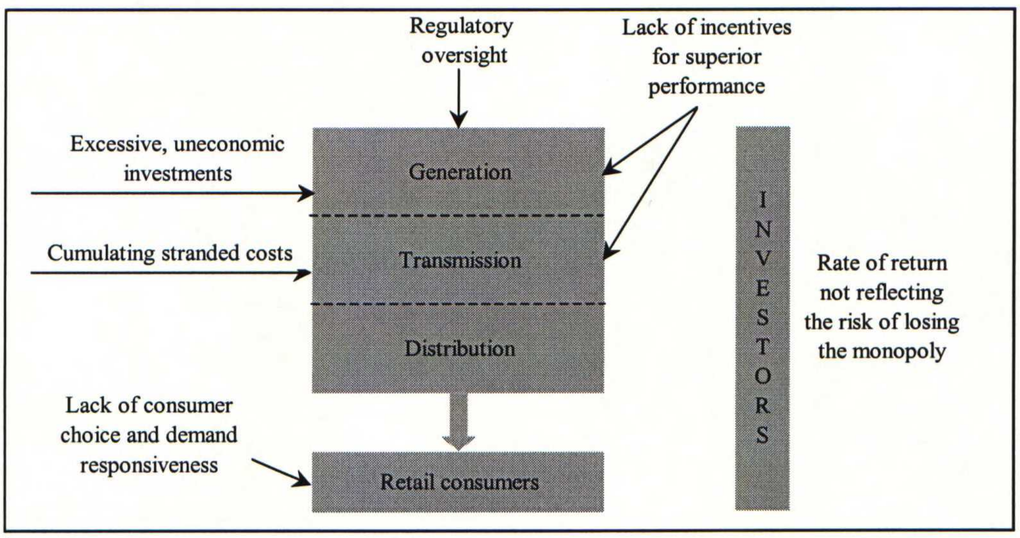

Figure 7 **The pre-reform market structure in California electricity markets and the inefficiencies involved**

[13] Priority service means a schedule of electricity rates, which increase with the level of reliability. Customers upon whom infrequent but uncertain service interruptions impose relatively low costs could save by subscribing to lower priced, lower priority service. Conversely, customers for whom interruptions impose high costs would subscribe to higher priced, more reliable service (Smith, 1989).

2.2.2 The Case of Finland

In the Finnish pre-reform markets, there were two levels, in which monopoly power could be exercised - the upper level, dominated by monopolies operating in power generation, high voltage transmission and wholesale trades and the lower level, dominated by distribution utilities attending to the low voltage distribution, retail sales and production (Lehto, 1995). The structure resulted in "multiplication of margins", because monopoly pricing was applied in two levels of vertical integration (Tirole, 1988). Also, the Finnish structure gave a better bargaining position to the producer in relation to the buyer, which created inefficient allocation of welfare, because the producer was able to transfer most of its financial risks to the customer. Further, the utilities were able to practice price discrimination policies – tariff structures, which deviated from market-based rates and favored some customer classes in expense of others. According to the different price discrimination degrees by Watson (1968), the Finnish case fell into the third degree of discrimination, in which the monopolist divides its customers into classes or groups and allocates sales between the markets so that the marginal revenues are equal[14].

Another recognized problem in Finnish pre-reform power markets was cross-subsidization. Cross-subsidization occurs when a company supplying more than one product or service uses the revenues from product A to recover a portion of the additional costs of producing product B. This pricing policy creates inefficiencies, because the consumers of product B receive incorrect price signals about the incremental costs of producing product B (Sidak and Spulber, 1998). According to the research of Kopsakangas-Savolainen (2002), the role of distribution companies in enabling cross-subsidization can be substantial in Finnish electricity markets. Namely, if the utility is vertically integrated and maximizes the *total* profit of supply and network units, the distribution unit, as a regional monopoly, can increase its distribution price to try to deter competition in its service area while the supply unit sets the energy price relatively low to gain competitive advantage. Consequently, extra profits can be gathered at group level both from higher sales volume in generation and increased margins in distribution.

[14] Rännäri (1992) tests the price discrimination of Finnish power utilities and the results pinpoint some level of discriminating features in pricing.

Cross subsidies fight against the spirit of free markets. Namely, they distort prices, serve equity goals ineffectively and redistribute wealth among various classes based on dubious conceptions about relative need. Cross-subsidization is in theory not viable in deregulated markets (VanDoren, 1998). This is due to the transparency in pricing, unbundling of utility functions and the better market signals for customers. Consequently, the deregulation can improve the markets markedly in this perspective, as well.

In Finland, the main producers saw the deregulation as an opportunity to loosen their political ties, which had prevented them to act independently. Especially the extensive government ownership in production and dominance in grid operations potentially created inefficiencies. However, from the reformers' point of view, the development of a more politically independent electricity sector was only one part of the reorganization issue. Instead, securing of common access to the national grid was perhaps even more important for a successful implementation of free, international trade (Bjorndalen, 1989).

Finally, the duopoly ownership structure of the national grid created inefficiencies. No real open access to the grid was allowed, which prevented competition. Moreover, limited number of power generators and the dominant role of IVO in wholesale level hindered competitive formation of price. Spot transactions (or rather temporary trade arrangements) were subordinate to the long-term contracts due to the risks of volatile spot prices in thin markets, and they only took place when there was no conflicts or explicit barriers in the way. Even though there had been cross-border trading between the Nordic countries over the last thirty years, increased welfare gains were expected to incur if border tariffs and significant bottlenecks in transmission infrastructure between the countries could be abolished and free trade in the Nordic markets would arise. Therefore, the increased Nordic power market integration and cooperation as well as pressures to follow the general development trend (led by the Norwegian deregulation in early 1990s) induced Finland and Sweden to deregulate their power markets (Midttun, 2000).[15].

[15] Sweden reformed its markets in January 1996. The Norwegian reform and the Swedish reform to some extent were motivated by economic incentives for trade between a thermal-based system (Sweden) and a hydro-based system (Norway). The benefits accrued from the different generating and cost characteristics of those methods (Halseth and Olsen, 2000).

Figure 8 illustrates the pre-reform market structure in Finland, the inefficiencies involved and the basic motivating forces to deregulate the markets. As the figure shows, IVO operates as a vertically integrated monopoly in every function of the distribution chain (generation, transmission and distribution).

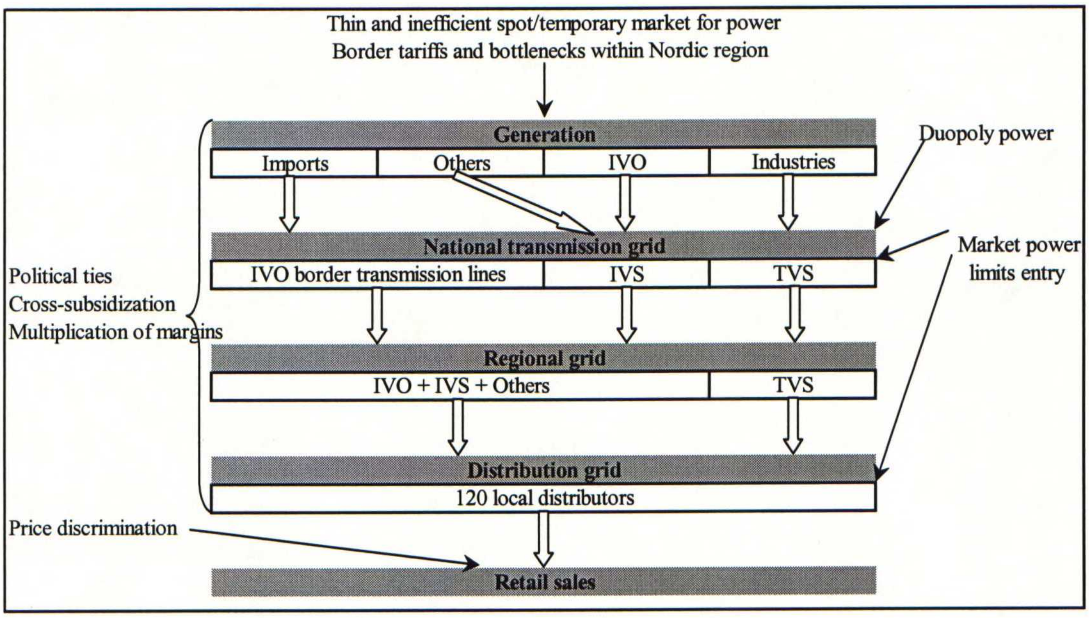

Figure 8 **Pre-reform electricity markets in Finland, the inefficiencies involved and basic motivations to deregulate the markets.**

The figure illustrates the vertical structure of pre-reform electricity markets. The thick white arrows indicate the flow of electricity from higher to lower levels in the distribution chain. The narrow black arrows indicate the inefficiencies and motivations to deregulate the markets.

Based on diverse pre-reform market structures and motives to change the structures, California and Finland approached the deregulation in different ways:

Pathway to deregulation in California - PURPA of 1978, Energy Policy Act of 1992 and FERC Orders 888 and 889

The Public Utility Regulatory Policies Act (PURPA), enacted in 1978, played an important role in helping to set the stage for a more dramatic reform of 1996 by stimulating the entry of independent power producers (IPPs) and creating a new competitive IPP-market against the existing utilities. The law primarily encouraged improvements in energy efficiency and increased the use of renewable fuels in power production by requiring utilities to purchase certain amounts of power produced by specified qualifying facilities (QFs) at "avoided cost" (Joskow, 2000)[16]. Energy Policy Act of 1992 further stimulated the competitive development in the U.S. power markets and cured some problems of the PUHCA. The law permitted utilities and non-utilities to have ownership interests in IPPs and extended the FERC's authority to order utilities to provide transmission/wheeling services for wholesale transactions. Finally, in 1996 the FERC set two additional orders, Order 888 and Order 889[17], to promote state-level deregulation frameworks and smooth the transition from old regimes to the new ones. Both of the orders advanced the non-discriminatory open access of networks and the introduction of transmission services available to all wholesale customers. More specifically, Order 888 established federal principles for stranded cost recovery, which was necessary for gaining full cooperation and support of incumbent utilities to the more fundamental changes in the market policies.

Pathway to deregulation in Finland – NORDEL

Finland had a different way of approaching its regulatory reforms of 1995. Namely, Finland joined the NORDEL cooperation of Nordic countries – inter-Nordic trade system set up in the 1960s, which created the preconditions for an integrated Nordic electricity market (Midttun, 2000). At least in theory, the NORDEL cooperation led to a short term optimization of trades between the countries, because the trade lowered the individual countries' reserve capacity requirements and demand in any point of time was met through the power plants with lowest variable costs. The principle of split-saving was used in pricing, which meant that the countries exchanged information about their marginal production costs and once there was a difference, trading took place at the average price of the two marginal costs. (Hjalmarsson, 1993).

[16] According to Rännäri (1997), the avoided cost-approach of the PURPA lead to a *monopsony* situation, where the surplus gained by customers in competitive markets was gathered by the purchasing utility. Consequently, no welfare gains from more competitive wholesale markets was channeled to consumers.

[17] Order 888 and Order 889 were called "Promoting Wholesale Competition through Open Access Non-Discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities" and "Open Access Same-Time Information Systems", respectively. Final rules were issued in April 24, 1996. 75 FERC 61,080 and 61,078.

2.3 General Objectives of Deregulation

Because competition is more effective than regulation in promoting efficiency, welfare and innovation, separation of potentially competitive parts of the electricity supply industry from the natural monopoly parts seems like a good policy. One of the well-known economic benefits of deregulated markets is that price signals to consumers and producers ensure efficient allocation of resources in both short- and long-run. This, of course, presumes that deregulated markets are competitive, since only then optimal allocations of resources can be produced (Reitzes et.al., 2000). California and Finland chose different approaches to deregulate, with varying objectives for competitive outcomes. Yet, the both markets shared the three basic objectives – welfare gains, efficiency improvements and higher level of innovation.

1. Efficiency Criteria

The unique ability of competitive markets is to provide strong efficiency incentives to competitors and to discover and meet the needs and wants of consumers (Olson, 2000; 19-20). Since regulation can, at best, only emulate the results of efficient competition among competitive firms the markets should be made free of regulatory ties and structured such that the pre-requisites for efficient competition are present.

Competitive markets improve efficiency and lower the cost of power. Herriott (1989) names three reasons for it. First, merit order dispatch, common to competitive markets, saves resources and reduces the cost of generating electricity, because power is always supplied to the transmission grid by the firm with the lowest marginal costs. Second, the wider variety of generating equipment and the larger number of independent producers in competitive markets add diversity to the system, lowering the probability of widespread equipment failure, and, thereby, reducing the amount of excess capacity required to provide a given level of service reliability. Third, because different plants could have different load characteristics, peak and load duration curves, generating capacity can be more fully utilized and additional capital resources saved when there are more generators operating in the markets. In addition to improving generation efficiency, deregulation will enhance transparency of prices, which enables better consumer choices and allows the emergence of efficient financial trade in electricity (Mork, 2001).

2. Welfare Criteria

Pareto optimality and neoclassical theory of pricing are closely related to the maximization of social and economic welfare. By combining these theories, it can be argued that welfare is maximized when it is impossible to make anyone better off without making someone worse off, and that situation occurs when the price is set equal to the marginal cost of production. To be more specific, the overall operational objective of electricity industry is the *maximization of combined, discounted supplier and consumer surplus*, which in practice requires the prices to equal the average long-run marginal costs (Hay, 1993).

Perfect competition maximizes welfare by diminishing monopoly power and related welfare losses. When it happens, consumer net surplus and welfare increase but the supplier surplus goes down to zero. Yet, total welfare is maximized, because higher consumer surplus outweighs the lost supplier surplus. Consequently, changes in the policies that deregulate markets always increase the wealth of some at the expense of others - electricity is no exception. In the switch to a competitive market, some high-cost facilities will not be able to earn revenues to pay their initial capital costs, and thus the market value of such facilities will be lower than their book value. This gap, i.e. stranded costs, can be compensated with the various regulatory recovery mechanisms (see e.g. Sidak and Spulber, 1998).

3. Innovation Criteria

Competitive pressure tends to make industries more innovative. Competition not only compels firms to be more responsive to consumer demands, monitor costs more closely, and compete on the basis of price, but it also gives an incentive to be innovative, because innovativeness can be the only way to gain superiority against the new rivals. Competitive generation envisions a market within which independent firms compete on the basis of price to sell electricity directly to large industrial customers (bulk wheeling), and to supply electricity, via common carrier transmission, to distributors who in turn sell power to final users (Rozels, 1989; Bushnell and Oren, 1994). The competitive market will also provide an array of innovative service standards that more closely match the diversity of consumer preferences (Caves et.al., 1989).

All of the above criteria can be achieved through increased competition in wholesale markets. The competition and hence the attainment of the criteria require the following:

I. *Efficient and robust spot markets and transmission mechanisms for wholesale power*

If several venues for trading exist, all arbitrage opportunities between the markets are captured. There are several independent actors in the market and no system barriers for cross-border trading and transmission exist.

II. *Efficient price formation in the spot markets*

Price and quantity are set on hourly basis at the intersection of aggregate demand and supply curves. The price is determined according to the marginal production costs (MPC) of the least efficient generator - occasional scarcity rents are allowed on top of MPC so that generators can recoup their long-run marginal costs (LRMC)[18]. Opportunities for system and area price manipulation are minimized.

III. *The spot and forward markets are allowed to operate freely*

No arbitrary caps for prices or barriers for contact hedging are constituted. The government involvement is minimized.

IV. *Excessive volatility and price spikes reflect only healthy economic signals and the price patterns remain reasonably predictable*

[18] Market clearing prices in excess of MPC (i.e. $P = MPC + scarcity\ rent$) perform a valuable service in rationing scarce capacity. Also, they enable the formation of the equilibrium, in which an optimal number of producers (in relation to capacity and load) operate in the market (Hughes and Parece, 2002; 39).

3 COMPARATIVE ANALYSIS OF THE DEREGULATORY PROCESSES IN CALIFORNIA AND FINLAND

3.1 Heavy-Handed vs. Light-Handed Approach

The regulators and government have a diverse set of interests – economic, distribution of wealth, environmental, social and national – determining the ultimate direction of deregulation (Mork, 2001). Under this framework, various approaches can be taken, all of which will fall into some point of the below axis in Figure 9:

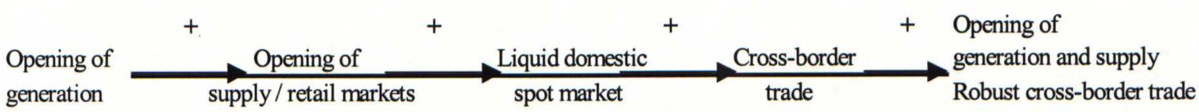

Figure 9 Continuum of different levels of deregulation.

Figure 9 shows that the lowest level of deregulation is the opening of up-stream generation markets. The physical and technical characteristics of electricity and its transmission mechanisms traditionally preclude the deregulation of grid operations (transmission and distribution), even though some theoretical outlines of such competitive transmission market have been suggested in literature (see e.g. Ramesh and Chatterjee, 1998)[19]. The extent of deregulation increases when moving from left to right in the line, the highest level being the opening of both wholesale and retail markets and the creation of an official cross-border (international) spot market for electricity.

The properties of the California market reform structure, transitional regimes and the electricity crisis of 2000-2001 never allowed California to reach functioning retail markets, let alone a liquid venue for cross-border wholesale trades with other states in the WSCC. Consequently, there was a period of time when the California generation market was competitive, but the outcomes of the crisis led to an ultimate re-regulation and market structure even worse than that of the pre-reform markets. Finland, on the other hand, received the full benefits of deregulation through its reforms of the late 1990s.

[19] The authors suggested a theoretical framework, where the underlying commodity would be "Transmission Capacity Use". The market would eliminate the need for regulation of grid operations and pricing.

The frameworks of the pre-reform regimes in California and Finland and the approaches necessary to restructure such markets necessitated California to take a "heavy-handed" approach while Finland managed with conducting a "light-handed" deregulatory process. Hence, the tight regulations in California markets compelled it to take stringent, comprehensive and progressive measures to withdraw from the old monopoly practices, whereas the informal self-regulation and the cultural orientation based on loyalty and cooperation allowed Finland to implement complete liberalization without harsh policy changes and amendments.

3.2 Regulatory Frameworks

To call liberalization of a certain industry "deregulation" is a little misleading in a sense that when the process takes place, new laws, which override the former ones, are passed, rather than abolishing the former ones altogether[20]. California approached the deregulation process by benchmarking the U.K. model (introduced in 1990) and taking influence on the federal initiatives, when passing the new law *Assembly Bill 1890* in September 1996 by a unanimous vote of the state Legislature. Finland on the other hand followed the initiative of other Nordic countries when adopting the new law *Electricity Market Act* in June 1995, independent of the EU Single Market Directives.

3.2.1 Assembly Bill 1890

In April 1994 the CPUC issued a report known as the "Blue Book", which laid out a set of structural and regulatory reforms for the power sector, including a proposal to unbundle generation from grid services (CPUC, 1994). The Republican Party has traditionally been minor to the Democratic Party in the California Legislature. However, a Republican was as a Governor in California and the CPUC administration was dominated by Republicans when the deregulatory proposals were initiated. Therefore, the traditional "republican values" governed the new market practice, a cornerstone of which was a total transition to a free market in the power industry.

[20] Actually, the term "restructuring" would serve the meaning better. Even so, in regard of this study, the terms are used interchangeably.

The Republicans acted for the interests of businesses and other market participants – the ratepayers being the least favored. Basically, the whole system was built upon a model structured by Republicans and their advocates and their values were reflected in the details of the deregulation law (Grandy, 2002). Not surprisingly, the proposal was first considered a radical reform, and opposed by regulated utilities (still enjoying the level profits based on accounting values of their assets) and retail customers (fearing that competition would benefit large customers at the expense of smaller customers). Despite the opposition, the California Legislature passed *The Electric Utility Industry Restructuring Act* (Assembly Bill 1890) in September 23, 1996 as an intention to change the market system that had been in place for more than eighty years. As of March 31, 1998, the new structure was implemented.

3.2.2 Electricity Market Act

One of the most important measures taken by the European Union (EU) in recent years has been the creation of a single market for electricity and gas, based on transparent regulation and open competition. The Commission's approach to deregulate has been to constitute a common set of regulatory principles, while leaving their detailed implementation to individual EU governments. The Single Market Directive for Electricity, entered into force in February 1999, was triggered by an unexpectedly rapid and far-reaching liberalization of several EU-countries (Jentsch and Müller, 2001).

Finland was one of the countries, which had already fully liberalized its power markets far beyond the minimum standards set by the EU when the power directive was entered into. The Finnish reform was framed into the *Electricity Market Act*, which was adopted in June 1, 1995. The adoption of the Act was followed by a three-year transition period, during which the Act was amended and practical issues relating to small-customer treatment and national network operations were defined.

3.3 Distribution of Oversight: the Role of Regulatory Authorities and Public Power

A deregulated power system must have a structure – a governance umbrella – that binds together the regional transmission system organization, unregulated market participants (generators, power marketers and brokers) and regulated market participants (transmission companies and public power entities). There are three basic approaches under this "governance umbrella" – competitive markets, contracts among parties and regulation. To achieve the maximum efficiency, the best combination of these three approaches has to be determined (Felder, 2002; 37). In the course of deregulation, establishment of new authorities and oversight entities as well as reassessment of powers enjoyed by the existing ones serves the interests of Felder's argument. Therefore, in almost every deregulated market new oversight organizations have emerged.

The distribution of oversight in restructured power markets in California and Finland differ from each other in various ways. The "dual-level" regulation in California has traditionally allocated the oversight between the federal level (Department of Energy, DOE, and FERC) and the state level (CPUC), whereas in Finland the oversight has been constituted to the state only, through utility ownership and certain laws. Deregulation in California increased the authority of the FERC but diminished the influence of the CPUC. In particular, the FERC gained regulatory power over the newly generated organizations and the wholesale power markets and heightened its authority over power transmission. The CPUC on the other hand lost its authority over governing wholesale prices, transmission operations and utility franchises. Since deregulation, the California Energy Commission's (CEC) duties have included initiation of several funding and R&D programs.

In Finland, the surveillance of the Ministry of Trade and Industry (MTI) changed in the course of deregulation, since e.g. no power plant authorizations were no longer needed in liberalized markets. Namely, Finland opted an "authorization procedure" for the construction of new plants (EU Single Market Report, 2000), which represents a transparent and effective mechanism, which leaves the decisions to the market instead of to some regulatory authority (Jentsch and Müller, 2001). The MTI still maintains the supervisory role in construction of power plants and trans-border power lines as well as the conversion of power plants to another fuel and the power imports and exports (Electricity Market Act, 1995, Chapter 9, Section 38). Much of the control enjoyed by the MTI was however delegated to its subordinates – Free Competition Authority (FCA) and Electricity Market Authority (EMA). Thus, the role of the FCA in power markets expanded as a consequence of deregulation - increased control was needed to curb the potential exercise of vertical and horizontal market power as well as discriminatory and unjust trade and pricing practices. Namely, the FCA aims at warranting competitive markets by ensuring sound and effective competition and taking initiatives and measures to eliminate harmful practices (www.kilpailuvirasto.fi).

In addition to the changes in the surveillance of the existing authorities, new oversight organizations were created in both California and Finland in the course of deregulation - all of which had the ultimate goal of supervising and facilitating the emergence of well-functioning and competitive electricity markets. In California, two new non-profit organizations were created – Independent System Operator (ISO) and California Power Exchange (PX)[21]. The ISO was appointed to be accountable for a sound operation of transmission by controlling and operating the networks owned by the three investor owned utilities (IOUs), running the energy balancing, ancillary service and congestion management markets, and coordinating these operations with the WSCC. In Finland, two new organizations were created in conjunction with the deregulation process. First, a separate legal entity not involved in production and distribution, Fingrid Plc., was established in 1996 to own and operate the transmission system. Second, an independent regulator subordinate to the MTI, Electricity Market Authority (EMA)[22], was founded 1995, at the same time the Electricity Market Act took effect, to monitor the implementation of the Act and the regulations issued under it.

Table 1 lists and compares the responsibilities of the different regulatory/supervisory bodies in California and Finland.

	California		*Finland*	
Existing Organizations' Responsibilities in Deregulated Markets	**FERC**	- Wholesale market surveillance: prices and transactions - Cross-border trades and transmission - Ensuring *just* and *reasonable* wholesale prices	**MTI**	- Energy infrastructure, conservation and efficiency - Energy taxation, supply capability and nuclear energy - International energy cooperation and nuclear power issues
	CPUC	- Control over retail prices (price caps) - Other duties such as transmission routing	**FCA**	- Discriminatory market power issues - Furthering of efficient competition - Restraining of monopolistic practices
	CEC	- State's primary policy and planning agency - Energy efficiency and renewable energy promotion - Demand forecasting, plant licencing		
New Organizations' Responsibilities	**ISO**	- Control and operation of power transmission - Control of the grids owned by IOU's (>90%) - Operation of balancing and transmission markets - Power scheduling - Market services and analyses	**Fingrid**	- National grid management: reliability and functionality - Planning and control of national grid operations - Grid investments, maintenance and development
			EMA	- Licencing network operation, monitoring pricing principles - Monitoring retailer's obligation to deliver power - Arbitration of case disputes

Table 1 **Responsibilities of the regulatory and supervisory bodies in California and Finnish deregulated electricity markets.**

[21] The PX was an official power exchange in which hourly price-quantity schedules were determined, based on aggregate market demand and supply. The PX is not particularly interesting in the context of market oversight and, as such, is discussed in more detail later in chapter 5.1.

[22] The name of the Authority was changed in August 2000 to Energy Market Authority, at the same time the Natural Gas Market Act took effect.

The FERC is a federal entity, thus acting as a superior energy regulator of all states in the U.S (except Texas). The chairman and the board members of the FERC are appointed by the U.S. President. The CEC and the CPUC are state regulatory entities and the state governor appoints their boards. The ISO is an independent organization, having independent board, appointed by the state governor or stakeholders (Jingchao, 2002). In Finland, the FCO and the EMA both are subordinate to the MTI. Fingrid Plc. has a mixed ownership: the Finnish government holds a 12% stake, Fortum Power and Heat and PVO equal shares of 25% and institutional investors 38%. In Figure 10, the important organizations of deregulated Finnish and California markets are plotted in an "authority matrix".

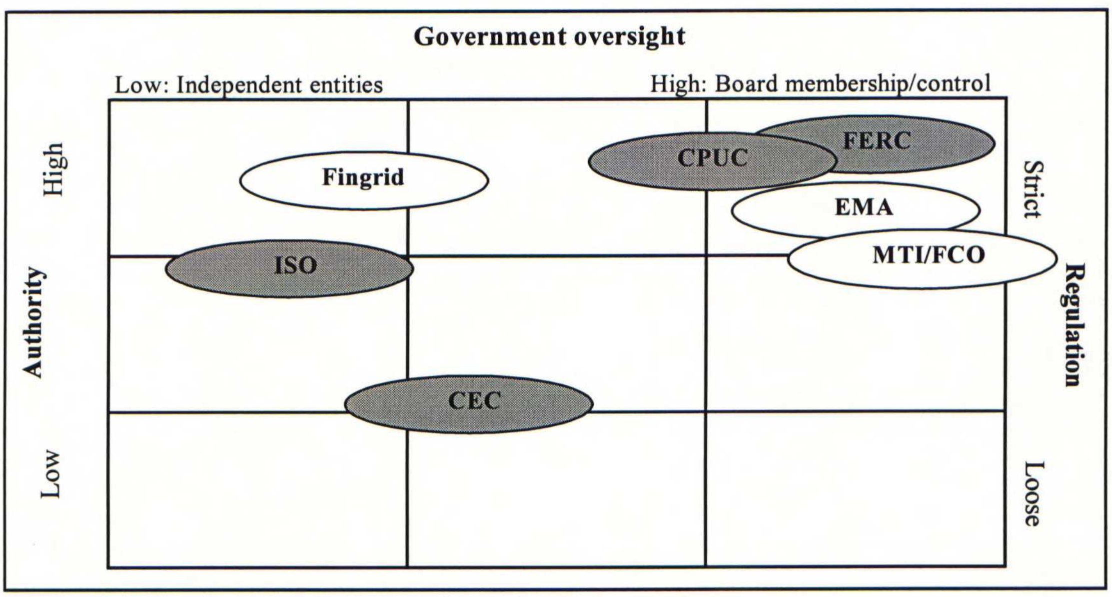

Figure 10 **Electricity market authority matrix. The governance entities are placed in the matrix according to the government oversight, authority and regulation.**

3.4 Unbundling

Competition in electric power production and supply calls for *open access* to the transmission and distribution wires and the regional monopoly franchise areas served by vertically integrated monopolies. Open access requires that any competing producer and supplier can use the grids and are faced by the same non-discriminatory terms and charges for those services (Hunt, 2002). It also requires unbundling of wholesale and retail markets, which means that the generation and transmission operations of existing monopolies are separated. The separation is necessary, since it effectively reduces the risk of utilities discriminating other participants in favor of their own generation and distribution subsidiaries when granting network access to competition.

3.4.1 Wholesale Level Unbundling

Competition in retail markets will not produce lower rates and welfare gains to consumers unless production markets are competitive. To be competitive, wholesale markets have to be unbundled and the barriers to entry removed. The unbundling in California and Finnish power markets was conducted differently - the design details of California model were heavily politicized and incorporated more detailed compensatory measures while Finland implemented full deregulation without biased or arbitrary mechanisms undermining the effects of deregulation.

In California, wholesale unbundling was administered by disintegrating the vertical utilities. Specifically, the three incumbent utilities (IOUs) were required to divest most of their generation plants and therefore became primarily transmission and distribution companies. As opposed to the Finnish approach of *ownership separation*, California required *operational separation* of generation and network operations. Thereby, the IOUs maintained as grid owners but the ISO was designated to operate the grid. Given decades of uneconomic investments together with privilege to a rate of return not commensurate to the risks involved, the utilities faced huge financial burdens within the transition to competitive markets. Thus, the book values of the utilities' assets exceeded their likely values in the competitive markets, which resulted in the stranded costs. Stranded costs are in close relation to the equivalence principle by Sidak and Spulber (1998; 393-402). The principle comprises four components, which have to be in equivalence because they all equal the firm's opportunity cost[23], thus the stranded costs. In addition, four conditions set the prerequisites for the application of the equivalence principle. Figure 11 sets forth the four components of the equivalence principle as well as the conditions necessary for the framework.

[23] In this context, a brief clarification of concepts is of importance. Namely, *regulatory contract* constitutes three principle components - price regulation, entry regulation and the obligation to serve – which jointly ensure the reasonable opportunity for the utility to recover the economic costs of its investments. *Deregulatory taking* and *breach of the regulatory contract* refer to the whole of the deregulation process.

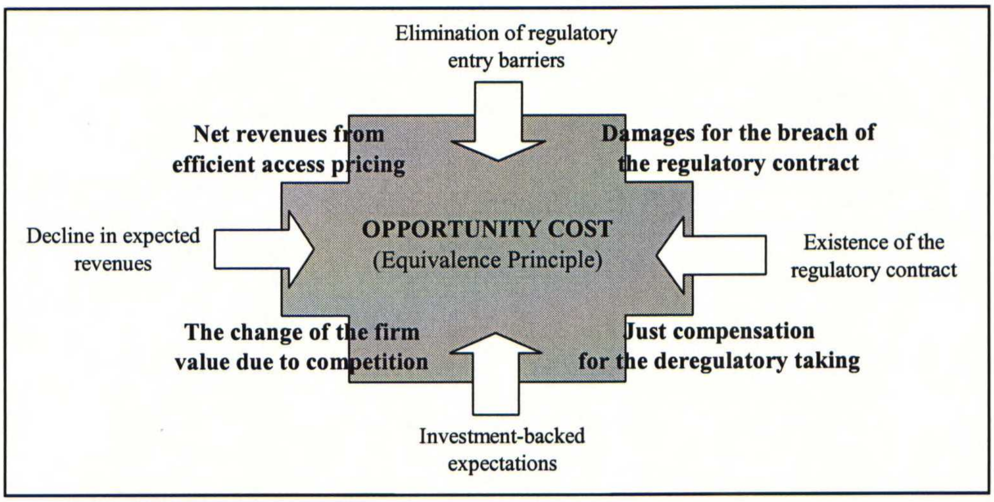

Figure 11 **The components of the equivalence principle and four conditions necessary for the application of the principle (marked with white arrows).**

The terms are revised from Sidak and Spulber (1998); the figure is constructed by the author.

Figure 11 indicates the ex ante economic consequences of wholesale unbundling of utilities. Indeed, since the regulators expect the competitive industry to be more efficient than the regulated utility industry subject to entry barriers, compensating the utilities for their stranded costs is efficient as well. Subsequently, in conjunction with the pricing issues, the quantification of the *opportunity cost* is introduced, applied to the concept of efficient access pricing and adapted to the transmission cost setting mechanisms of California and Finland.

European Commission stipulates[24] that the EU Member States must vertically unbundle the power sector to ensure transparency and competition and to grant indiscriminate access for third parties to the network (Jentsch and Müller, 2001; 21). In practice, the separation, or "management unbundling", of generation and grid operations should be carried out. In Finland, a full ownership separation was conducted and an impartial transmission company, Fingrid Plc., was set to own and operate transmission. This practice obviously had a potential to solve almost all concerns of discrimination, because the incentive and ability to discriminate was eliminated. Yet, some practitioners argue that ownership separation can cause legal obstacles and opposition from the utilities, which stand to lose

[24] The Commission's Internal Electricity Market Directive (96/92/EC), effective on February 19, 1999. The Directive respesents a "watershed" for the EU power market liberalization. In practice, it did not affect Finland's liberalization process, since the Finnish reforms had already been fully conducted by then. Still, the Directive reflects the same principles that underlie the Electricity Market Act of 1995.

the most when they no longer have the ownership and control over the grid. Additionally, ownership separation can potentially distort investment decisions in generation, because of the close substitute nature of generation and transmission. So, if the investments are limited to either transmission or generation, the lack of coordination in investment decisions can result in rejection of otherwise economically viable investments. (OECD/IEA, 2001; 38).

However, in Finland the negative effects of ownership separation are not likely due to the state ownership stakes in both of the former grid companies (IVS and TVS), which clearly mitigates the utility opposition and reduces the need to compensate them for the financial losses of unbundling. In effect, no eminent problems in investment decisions or utility resistance were seen in Finland. Therefore, no measures such as those in California power markets were due in Finland to compensate for the breach of the regulatory contract - even though nuclear power remained an integral source of power and could have potentially caused stranded costs in transition to free markets[25]. Instead, the charges for recovery of stranded costs were implicitly embedded in energy-based fees.

Another special characteristic in the Finnish power market reform was its neutrality to ownership. Thus, the reform did not require privatization, but largely left public ownership intact. The system was dominated by competitive public capitalism, which also had considerable inputs of private capitalism – this peculiar mixture of public ownership and competitive exposure reflects a Nordic tradition of pragmatic social democracy (Midttun, 2000). By that means, the Finnish reform differed from that of California in a sense that the public sector in Finland stayed in a pivotal role even after deregulation.

3.4.2 Retail Level Unbundling

Competitive markets in retail level effectively create more choices and more diverse services for all customers and can be achieved if wholesale markets are working (Hunt, 2002). To put it differently, wholesale unbundling is naturally followed by retail unbundling and, working competitively, this mechanism conveys the efficiency, innovation and welfare gains from the production level to the final end-users.

[25] High investment risks of nuclear power and difficulties in integrating the facilities to the competitive market have a potential to cause such problems as excessive non-recoverable investment costs and uneconomic dispatch.

Even though the introduction of retail competition in California was a primary part of the "Blue Book" (CPUC, 1994), the mechanism of "efficiency transfer" from wholesale level to retail level never worked quite according to the theory of deregulation. Indeed, the reform embodied the elements of default provision and competitive entry but seriously lacked the customer responsiveness. More accurately, the IOUs were placed to provide default service to customers who did not choose to access competitive marketplace, but legislatively froze the default service rates for a transition period[26], to allow the nascent competitive market to develop and customers to get used to the prospect of purchasing electricity from some other than their existing utility (Smith, 2002). In effect, the frozen rates, working as a safety net for customers against volatile prices, created only little incentive to respond to the emergence of the retail competition. Since the retail rate was set fairly low (to give the customers the immediate benefits of deregulation) and not adjusted to changing market conditions, demand elasticity of the price was essentially zero. To sum up, California did not deregulate the prices the utilities could charge their customers, but instead created a joint mechanism of utility stranded cost recovery and consumer isolation to compensate the utilities and smooth the transition into free markets.

In Finland, operations of the regional and local distribution networks were not *legally* unbundled but the distributors had to separate network operations, electricity sales and generation from each other by setting apart their accounts and making the financial information public (EU, 2000). This provision of making terms, charges and pricing criteria of supply activities transparent and public intended to curb non-discriminatory practices. In effect, the problem of cross-subsidization was never eliminated, since the horizontal and vertical integration indeed intensified. Namely, the number of distribution companies in Finland has decreased from the pre-reform levels - in 1995 117 companies operated in distribution markets while the number was only 98 in the beginning of 2002 (Finergy, 2002). This trend has partly been an outcome of structural arrangements and intensive M&A activity. That is, large utilities (such as Fortum Heat and Power, the Swedish Vattenfall and some utilities from continental Europe) have taken a strategy of increasing their horizontal market share in Finnish power markets by purchasing regional utilities.

[26] The transition period started in April 1998 and ended in March 2002, or when the IOUs recovered their stranded costs, whichever came first.

In Finland, the transition to the free market in retail level has occurred gradually after the Electricity Market Act took effect in 1995. Even though only separation of accounts of the distributors was required, all consumers with a power requirement exceeding 500 kW have been free to choose between suppliers since June 1995, followed by a complete opening of the market in 1997. Also, directed by the Act, all vendors have been obliged to give an *itemized account* of what the price of electricity consists of when invoicing their customers. Nevertheless, only small proportion of residential customers in Finland has switched from their default service provider to a competitor supplying power with more advantageous terms. The Electricity Market Act defines the default service provider as "an electricity retailer, which has an obligation to deliver electricity at reasonable prices upon request of a customer if the customer has no other economically competitive opportunities to buy electricity via the power network" (Electricity Market Act, Chapter 6, Section 21, 466/1999).

3.5 Pricing

According to the Pareto Optimum Theory, efficient pricing of power increases overall welfare by ensuring that customers do not demand more of the good than they really value and, over time, the resources are allocated to their highest valued users (Warner et.al. 1999). Most jurisdictions have concluded that some level of regulation needs to be in place to achieve efficient retail prices in deregulated markets. Price regulation can be organized either with various price-setting mechanisms (such as caps and floors) or with lighter approaches, such as indirect public scrutiny and the threat of regulation. In California, the authorities intervened heavily the power markets, while in Finland, price caps or other measures alike were never needed, since the markets were not expected to experience such price shocks that control would have been necessary.

3.5.1 Rate-Setting Mechanisms

In California, the reform appointed the retail power prices to be frozen to the pre-reform levels of year 1996, which averaged \$60/MWh. The retail rate was constructed as follows:

$$R_{RETAIL} = W + (T \,\&\, D) + F + CTC \qquad (3)$$

where *W* denotes the wholesale electricity price, determined monthly, *T&D* fixed and regulated transmission and distribution charges, *F* other fixed charges (nuclear decommissioning costs, public purpose program and bond refinancing charges) and *CTC* competition transition charge (a residual component set up to recover the utilities' stranded costs) (Smith, 2002; 26). In addition to protecting customers from price fluctuations, the underlying idea of the this rate mechanism was to secure and increase the velocity of the recovery of stranded costs, since wholesale electricity prices were expected to be far below the frozen rates and fall even further in the future. Once the stranded costs were recovered, the IOUs would switch to simply shifting the wholesale prices of power to the retail rates. Figure 12 depicts the rate setting mechanism in California.

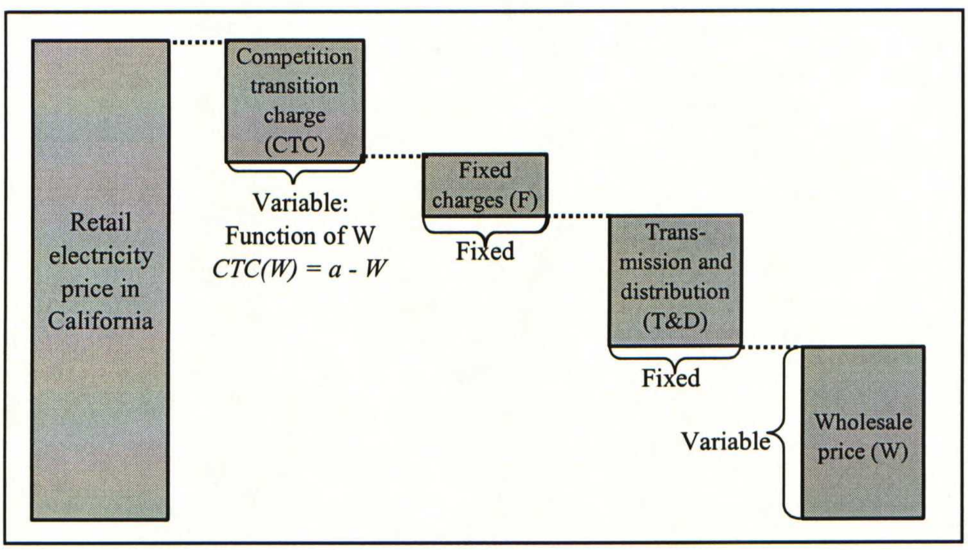

Figure 12 **Rate setting mechanism in California power markets: a composition of the frozen retail electricity price.**

The retail price was frozen to approximately $60 / MWh. Transmission and distribution charges (T&D) remained regulated and fixed. The CTC charge was variable and inversely related to the wholesale price. The wholesale price was determined on a monthly basis in the official spot market based on aggregate supply and demand bids.

In Finland, the overall objective concerning the retail prices in deregulated markets was to secure their reasonableness[27], which requires transparency through unbundling of accounts of the monopoly

[27] "*The net operator shall have the right to charge a reasonable fee to cover the costs of connection and operation to the network.*" (Electricity Market Act, 1995, Chapter 5, Section 17). Paananen (1998) specifies the definition as follows: the net operator/power vendor sets the tariffs within the framework of law. So, the profit from the company to its owners must not be too great, principle of equivalence has to prevail between prices and costs caused by customers and the difference between price level and the minimum costs must not be to great.

activities (i.e. the regulated transmission and distribution functions) as well as publicity of prices. According to Kauppa- ja Teollisuusministeriö (1994) the publicity requirement and the Act of Competition Restrictions of FCA are sufficient enough to ensure reasonable pricing and to restrain cross-subsidization and monopolistic pricing practices. Figure 13 shows the potential direct and indirect channels of oversight in Finnish electricity markets, concerning retail pricing (Lehto, 1995). Channel A refers to an indirect effect of publicity and transparency on prices, where customers enforce the utilities to adjust prices to avoid losing them in the competitive markets. Channel B portrays a direct effect of publicity and transparency on prices through a *self-regulation effect*. Finally, channel C represents an indirect price effect of active authority overseeing the reasonableness of prices.

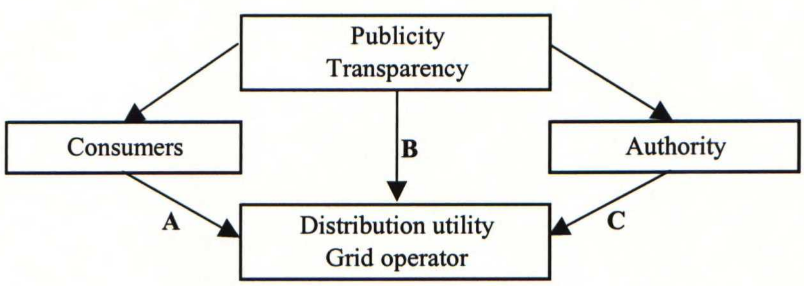

Figure 13 **The oversight mechanism of retail prices in Finnish power markets: indirect and direct channels of influence [Lehto (1995; 62)].**

Gronli (2001) compares the different price regulation practices in Scandinavian electricity markets and concludes that the Finnish model is characterized as a "light-handed" ex post regulation. The regulation is in effect only implicit and based on investigative practices rather than direct decrees. In particular, the Finnish application of a rate-of-return (ROR) and cost-plus price regulation necessitates "case-by-case" regulation of pricing practices after the fact – only at the request of customer complaints and based on real, ex post, financial data. This practice aims at assuring reasonable and efficient prices as well as efficiency of utility operations. Efficiency measurements in Finland are based on a data envelopment analysis (DEA), upheld by the EMA, which can potentially contribute to the advancement of the deregulation process by facilitating comparisons between the different utility pricing practices, and support decisions to switch suppliers.

3.5.2 Transmission Pricing

Efficient transmission pricing means that prices should equal marginal costs, which consist of marginal line losses and, in case of congestion, congestion rents (Lenard and Lips, 1997). Also, efficiency enables economic dispatch of generating resources and appropriate decisions between generation and transmission investments. Finally, efficient prices allow profitable entry of new participants (a primary precondition of competitive markets) and cover the opportunity costs of the utility, pursuant to the equivalence principle. In effect, the *Efficient Component-Pricing Rule (ECPR)* sets the transmission price so that the above preconditions are fulfilled (see e.g. Baumol and Sidak, 1994 for further analysis of the efficiency of the ECPR). The ECPR defines the access price[28] as follows: *access price = incremental cost of providing access + opportunity cost of providing access*, and quantitatively, $A = b + \Delta / X$, where b equals the utility's cost of providing access, Δ the opportunity cost and X the sales of access. Therefore, the ECPR effectively determines the regulated component of the final retail price of customers.

Different methods to meet the above pricing objectives were developed in California and Finland. In California, a *point-to-point* or a *zonal* pricing method is used, which sets the transmission price to equal the sum of capital cost (line losses for high and low voltages) and congestion charge (Jingchao, 2002). The congestion charges result in two separate market clearing prices to emerge in Northern and Southern California and at each point of interconnection between the ISO's facilities and those of neighbouring transmission operators. Backerman et. al. (1996) argue, based on their empirical analysis, that the California framework does not result in efficient transmission prices due to the false price signals under the system operated by a "passive ISO". The analysis evidenced that since the ISO ignores opportunity cost principles in pricing transmission, congestion costs become distorted and thus send wrong signals about investment requirements in generation and transmission. This phenomenon can be attributed to spatial market power exercised by the utility, which distorts its congestion and makes extra profits from it (Skytte, 1999).

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[28] I.e. the transmission price to compensate the use of the grid owned by the utility (the IOUs in California) or an independent grid company / regional grid operators (Fingrid Plc. / regional distribution utilities in Finland).

Conversely, in Finland, a point-tariff system is adapted, which sets the transmission tariffs to be independent of the geographical distance[29]. In effect, the tariffs are not dependent on sellers of the electricity, nor the purpose for which the electricity is used (Paananen, 1998). Indeed, the Finnish system resembles a more "market-based" approach in terms of transmission and therefore does not incorporate the problems related to the above-described ISO framework. The fact that the decisions in the transmission function in Finland are not guided by political considerations (like those in the California ISO framework) but rather by efficiency considerations supports the argument. Besides, Gronli (2001; 61) concludes in her analysis of pros and cons of the Nordic regulation models that the "threat of regulation" approach in Finland provides better incentives for efficient grid operations.

3.5.3 Price Controls

Open functioning of the market is the best way to ensure competitive electricity prices. Still, there are certain situations where corrective market action or other remedies have to be taken to ensure that the market continues to function in a fair and efficient manner. California ISO (2002) designates as one of its "response actions" the imposition of bid caps and floors as a measure to mitigate anti-competitiveness of the deregulated power markets[30]. Namely, in California wholesale spot markets price caps were constituted by the FERC soon after the markets commenced operations in April 1, 1998. (Alexander and Irwin, 1996). Varying levels of price caps have been in effect since then, depending on market situations. In Finland, it appears that the deregulation design has enabled the markets to work fairly competitively and, therefore, adoption of such measures has never been considered necessary.

[29] The network service fee comprise distribution, national grid transmission and regional grid transmission prices. These charges accounted for 32%, 3% and 2% of the total retail electricity price for households in 2001, respectively. Other components, power procurement, power sales and taxes, took 31%, 6% and 26%, respectively (www.energiamarkkinavirasto.fi). The EMA sets Fingrid's transmission tariffs in constant nominal prices for a period of three years (Henney and Russell, 2000).

[30] The other four mitigating measures specified by the California ISO were (1) the change of market rules in tariffs and protocols, (2) developing data requirements for market participants (3) imposing sanctions and fines and (4) reporting to regulatory agencies. In fact, the ISO has used all of these measures at least at some level since it began its operations in April 1998.

3.6 Stimulation of Competition in the New Wholesale Markets

In California, the stimulation of competition in wholesale markets was engineered by advising the three IOUs to divest a major part of their gas-fired generation assets to independent generators[31]. In particular, sufficient diversity of ownership had to be attained to have a robust wholesale market for electricity - with right economic price signals, competitive price formation and free and nondiscriminatory entry. The California Power Exchange (PX) was set up to work as an official *mandatory* uniform-price auction market, where centralized supply and demand-side bidding could take place, resulting in competitive prices reflecting the marginal costs of the least efficient generator. The IOUs were compelled to bid all the power they could supply from their own generating assets and the existing contracts with IPPs to the PX and, accordingly, to buy the power needed to cover the default service demands of their customers. Moreover, to ensure market robustness, the utilities' ability to hedge their short positions was restricted by the CPUC.

In the Nordic region, the long-term objective has been to extend the domestic competition across national borders by allowing and promoting beneficial cross-border trade. The idea is to optimize the seasonal fluctuations in supply and demand and ensure the adequacy of resources at all times by combining the abundant hydropower resources in Norway and Sweden with the Finnish and Danish condensing power. As a consequence, the Electricity Market Act of 1995 removed the barriers of imports and exports with Finland and Sweden in 1998 and the Finnish power exchange EL-EX was merged into Nord Pool, which has since June 15, 1998 provided a system spot price for Finland as well as an area price for the Finnish price zone. Borenstein and Bushnell (2000) argue that one of the most straightforward and economic ways to promote competition is to increase the contestability of separate geographical markets by beefing up the transmission infrastructure that serves them. This is just what came about in Nordic countries – in the course of deregulation the border tariffs between the countries were eliminated. Accordingly, the participants had incentives to bid competitively and operate economically prudently due to the threat of competitive imports.

EL-EX was created in 1995 as a response to the market deregulation. Its goal was to increase competition, ensure efficient and transparent hourly price formation in the power market and prepare

[31] In effect, these generators were only in number of five (named Duke Energy, AES Corp., Dynergy, Mirant and Reliant). Thus, the preconditions for robust competition were not especially favourable.

the domestic market for deeper integration within the Nordic region (Iivanainen, 2001). Nord Pool is an official Nordic power market for cross-boarder trades, characterized by a high number of firms, none of them having especially significant market share in the generation activity. It is also highly dependent on hydropower and thus water reservoirs in Norway and Sweden as well as seasonal variations (rainfalls and temperature). Yet, due to the high usage of hydropower, Nord Pool has most of the time been one of the places where electricity has low prices (Herguera, 2000).

In addition to removing the border tariffs, Finland overhauled its energy taxation system at the beginning of 1997. In particular, the taxing of fuels (raw materials of electricity) was switched into taxing the electricity itself. The reason for the reform was to alleviate trade with other Nordic countries and to make domestically generated electricity more competitive with Nordic imports (Ministry of Trade and Industry, 1999).

Nord Pool is a *voluntary* power exchange. Consequently, only a minority of Finnish wholesale power trades was channeled through the exchange during its first years of operation. Most of the trades are conducted with bilateral long-term contacts, but the spot price is increasingly used as a benchmark in pricing the contracts. After 2005 most of the long-term bilateral contracts will expire, after which none are intend to be entered into. This will potentially mean increased use of Nord Pool in trading wholesale electricity (Mattila, 2002). The major obstacles for increased use of the exchange might be related to risk aversion (volatile spot price), commitment to existing long-term contracts and a large number of industries producing their own power and pricing it according to the average costs. Along with the trades taking place in the power exchange and the bilateral fixed-price contracts, three "private pools" operate in Finland. Namely, wholesale power sellers in Finland can roughly be categorized into three pools – IVO, TSM (Teollisuuden Sähkönmyynti Oy, which has since 1995 taken over the wholesale trades of TVS) and a group of industrial companies and utilities selling power under long-term contracts (Kärkkäinen and Rajala, 1999).

3.7 Summary of the Comparative Analysis

In the course of this chapter, several eminent gaps between the deregulatory models taken in California and Finland were discussed and their theoretical backgrounds analyzed. Most of the variations in the models appear to derive from the fundamental differences in the pre-reform market structures and different corporate, cultural, regulatory and political orientations in the respective jurisdictions as well as some century-old business practices in the energy industry. Finally, some of the differences are simply attributable to the geographical and natural resource characteristics of the markets. Figure 14 portrays the whole framework of deregulation – the contributing factors in the specific deregulatory models chosen as well as the concrete characteristics in the deregulatory approaches in California and Finland. Also, the withdrawal from the old "engineer framework" to the new free-market oriented "economic framework" is illustrated.

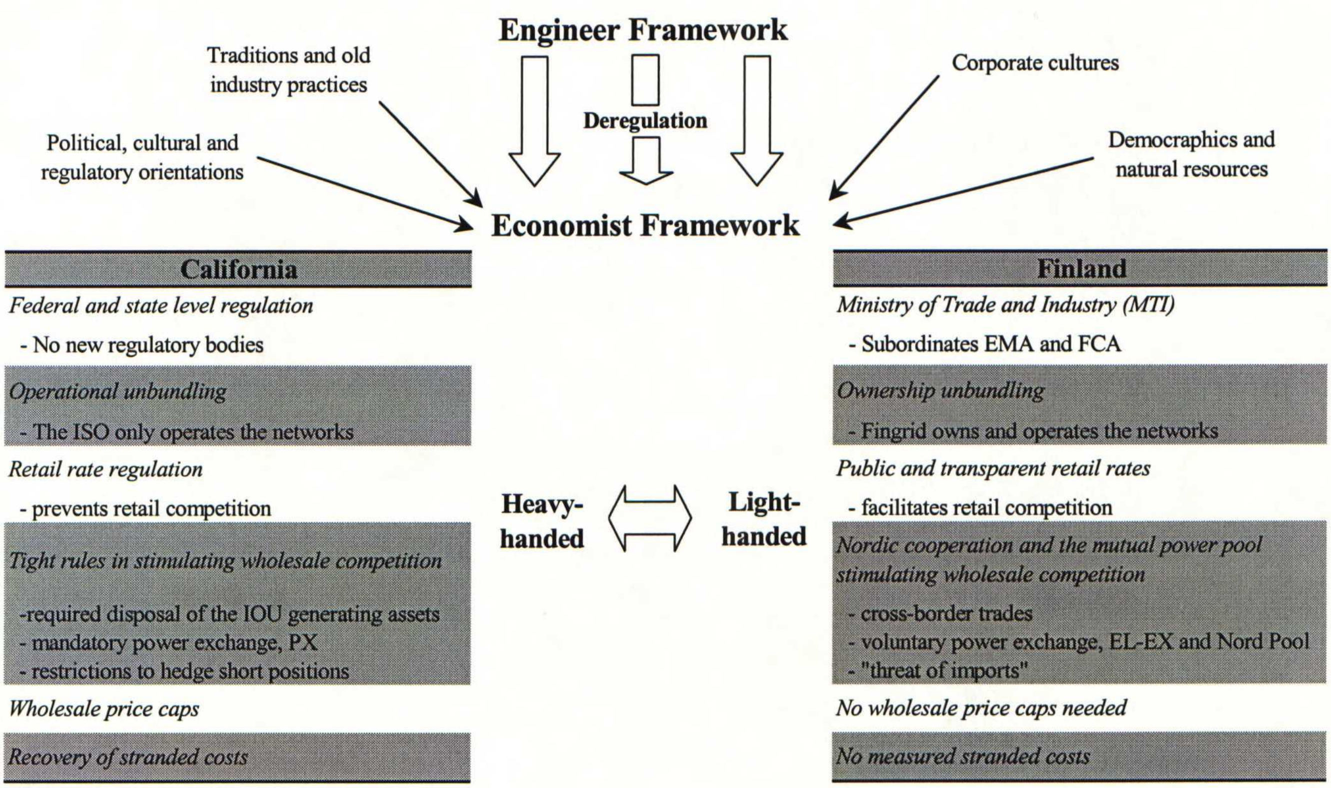

Figure 14 **Different deregulatory approaches under the "Economist Framework" in California and Finland – derived from the "Engineer Framework" pre-reform market structures.**

Most of the elements of the deregulatory models in California and Finland have direct and important implications for the competitiveness, extensiveness and success of the reforms. Figure 15 lists the most important elements of the respective deregulatory models and values their importance in facilitating competition in deregulated markets.

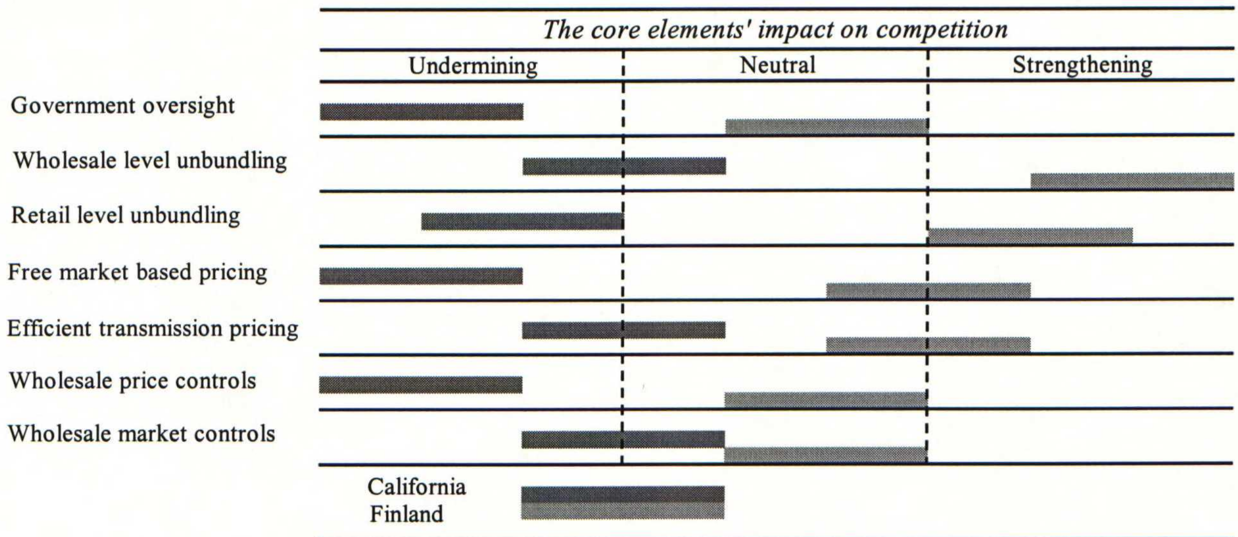

Figure 15 **The core elements of the deregulatory models in California and Finland and their impacts on competition.**

The colored bars represent the elements' contributions in creating competition in the deregulated markets in California and Finland. They are the author's importance estimates.

Figure 15 shows that the government oversight undermines competition in the California markets, while its role is neutral in the Finnish markets. The undermining role in the California markets derives from the regulations and strict overall federal and state rules. In Finland, the responsive and interactive role of the MTI and its subordinates explains their neutrality to competition. Wholesale and retail level unbundling was more extensive in Finland than in California. In effect, in Finland full unbundling was conducted in both levels, although in retail level only separation of accounts was required and consolidation of companies lead to more vertical integration. In California only operational unbundling was conducted in wholesale level and the rate freeze precluded competition in retail level.

The point-tariff transmission pricing system and free formation of retail rates in Finland explain their neutral impacts on competition in Finland, while the zonal pricing system and rate regulations in California markets contribute to the corresponding pricing elements' positions in Figure 15. Extensive control in California wholesale markets, encompassing wholesale price caps, restrictions to hedge positions, instructed asset disposals and mandatory use of the power exchange, explains the control elements' undermining impact on competition. In contrast, no wholesale price caps were constituted in Finland and the market controls have been kept at a moderate level.

4 SPOT MARKETS AND PRICING IN DEREGULATED POWER MARKETS - ECONOMIC IMPLICATIONS FOR EFFICIENCY AND WELFARE GAINS

4.1 Special Characteristics of Electricity

Electricity trading is organized just like any commodity trading. Moreover, electricity is often classified as a commodity product. However, by definition, electricity is not really a commodity, since it is not something you can store[32], touch or transform. The non-storability characteristic of electricity is critical because it prevents the use of inventories to arbitrage prices over time. Consequently, arbitrage assumptions, such as those used in Black & Scholes option pricing models cannot be used in pricing electricity securities[33]. Physical characteristics of electricity make it different from other commodities. Namely, *Kirchoff's laws* let power to follow a path of least resistance and, as such, power injected at any one location in a network can affect the availability of transmission capacity elsewhere (Lenard and Lips, 1997). Eventually, stability of the entire power grid can be in danger. This "loop-flow" characteristic justifies the view that power systems require some form of centralized control (ISO and Fingrid) to work properly and reliably.

Some special price characteristics of electricity in efficiently functioning markets differentiate it from other commodities and equities, as well. These temporal and distributional characteristics include three core elements. First, electricity prices incorporate a high degree of persistence in both price level and squared prices. Thus, in contrast to equities, electricity prices do not follow a random drift but are instead auto-correlated. Second, electric power prices show clear and consistent intra-day, day of

[32] In effect, electricity can be stored, but it is extremely expensive. Such storing technologies as pumping water uphill (in hydropower facilities) or batteries are not cost-efficient nor viable long-run solutions.

[33] Nonetheless, *inter-temporal arbitrage* can occur, if consumers are flexible in timing or quantity of their purchases. In that case, prices adjust above marginal production cost (MPC) at times to clear the market and thus the prices change only slowly over time (Wilson, 2000) and price spikes are avoided. However, such demand responsiveness is quite rare in deregulated markets.

week and seasonal cycles, which derives from electricity's high sensitivity to weather conditions. Third, electricity prices incorporate "inverse leverage effects"[34] - price volatility responds asymmetrically to negative and positive price shocks due to the efficient dispatch assumption of convex marginal costs (Knittel and Roberts, 2001). Finally, electricity prices evidence extensive positive skewness and kurtosis and thus depart notably from normal distribution.

4.2 Economics of Price Volatility

Pricing distortions and excessive price spikes will inevitably arise during the transition from regulated public utilities to more competitive marketplace and open-access networks. Indeed, in deregulated markets utilities are no longer able to simply bundle all the incurred costs and an appropriate profit margin in the prices - the prices vary in the spot markets according to the aggregate supply and demand, instead. Figure 16 illustrates the main contributing factors to the volatility of electricity prices.

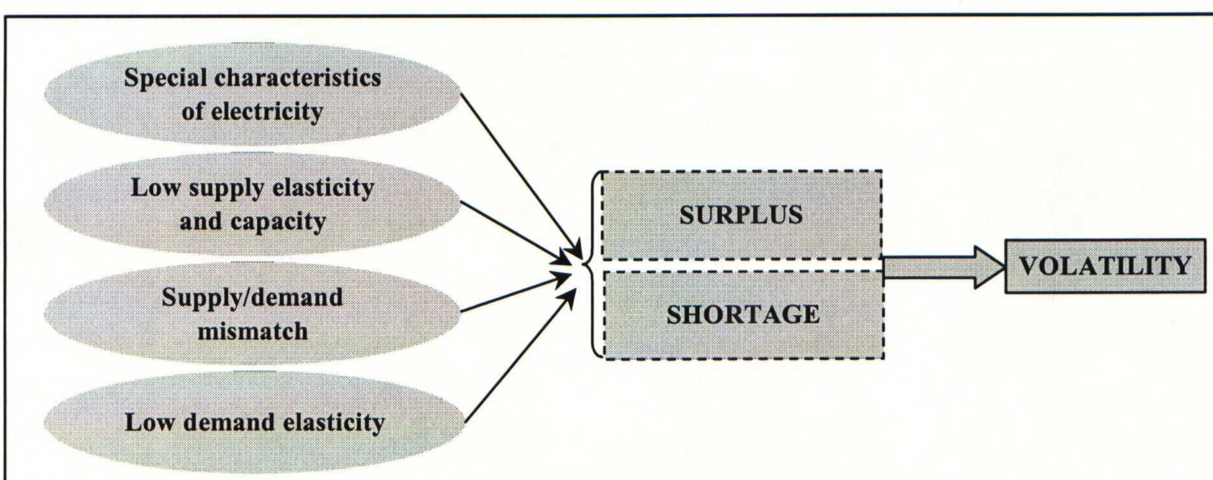

Figure 16 The main factors causing electricity price volatility in deregulated markets.

Special characteristics of electricity, discussed in previous chapter, contribute to price volatility in causing volatility "clustering" and unpredictability in timing of such shocks. Low supply elasticity

[34] This notion comes from Black's (1976) theory of a "leverage effect", which states that *negative* price shocks are followed by excessive volatility. This is due to increased leverage, when equity value reduces in relation to debt and consequently increases inherent risks.

refers to the capital-intensity of the power industry. More accurately, there are considerable lead times when adjusting rigid generating capacity to changing market conditions. This causes prices to soar in tight supply conditions, because the economics of time-discounting prevent new entry to occur in a timely manner to balance the supply and demand. Capacity constraints are a result of the costly storage of power. Since idle capacity is kept at a minimum level, it is impossible to scale up production in the event of excessive demand. Low demand elasticity is a common feature in power markets – electricity is a necessity product and thus highly insensitive to price movements[35]. Opportunities to exercise market power usually derive from the four other factors causing the volatility by exacerbating the volatility and reducing the possibility for prices to recover to their "normal" levels.

Figure 17 illustrates the effect that low supply and demand elasticities can have on prices. The figure presents two demand scenarios, A and B, in which the inelastic demand ranges between low (L) and high (H) ends. The inelastic supply curve[36] causes prices to fluctuate immoderately - only small horizontal shift to right in demand scenario (from A to B) causes the price to go to infinity and a shortage to occur.

[35] In the newly-generated California and Finnish electricity markets, no such elasticity-enhancing demand responsiveness technologies were available (like time-of-use metering systems). Earle (2000) argues that in the California markets the elasticity of demand is often considered to range from zero to about -0.1 - -0.3. The real-time demand elasticity often equals zero while the day-ahead demand elasticity is higher, due to the multiple opportunities to buy and sell power in the subsequent markets.

[36] The shape of the supply curve reflects the fact that in high volumes, the base-capacity is completely used, and additional capacity has to be taken from less efficient and more costly sources (often serving only peaking power).

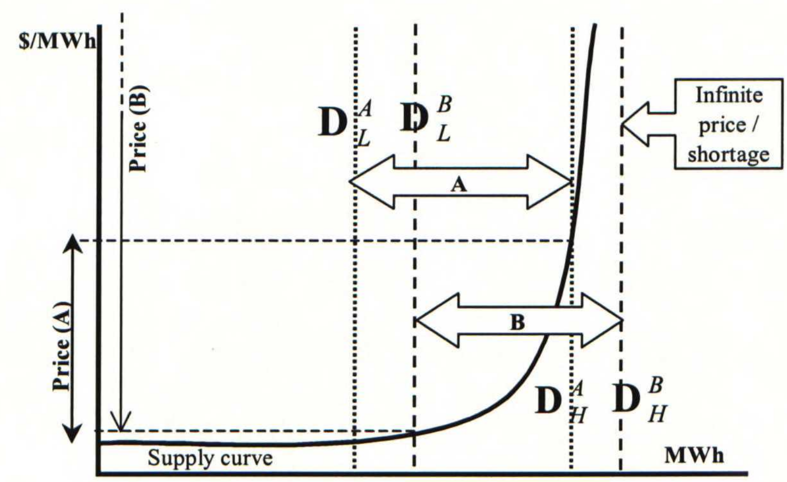

Figure 17 **Electricity price formation in a market of inelastic supply and demand [revised from Borenstein (2001)].**

Two different demand scenarios, A and B, illustrate high price volatility: in the high end of the scenario B, price goes to infinity and a shortage takes place.

4.3 Electricity Wholesale Market Efficiency

There can be two distinct sources of inefficiency in wholesale electricity markets – physical and trading inefficiency. Most of the studies observe only physical market efficiency but to get a comprehensive picture of the overall efficiency (or competitiveness) of the markets, both of the aspects should be considered.

4.3.1 Physical efficiency

Physical efficiency of markets relates to the competitiveness of the auction, where suppliers and buyers quote their respective bids according to their marginal opportunity costs. Theoretically, a producer in a competitive market is always ready to sell a unit of power if the price is higher than the marginal cost of producing that unit or the opportunity cost of selling it elsewhere. Figure 18 portrays the competitive bidding process, where the price is set at the intersection of the aggregate (inelastic) demand and aggregate supply.

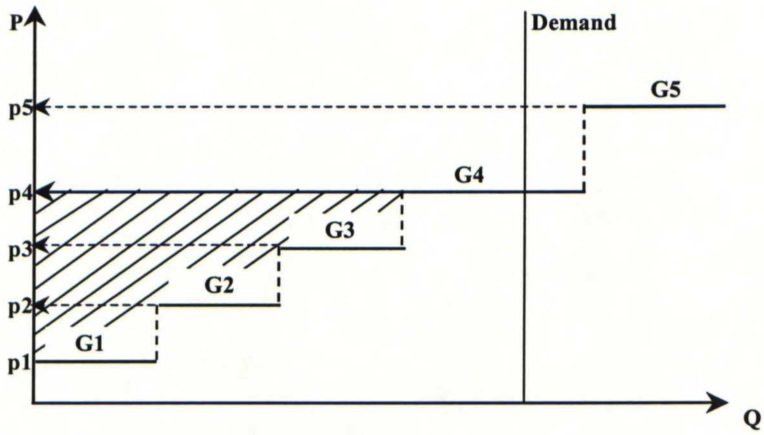

Figure 18 **Portrayal of a bidding process and price formation mechanism in a physically efficient uniform-price power auction.**

The generating companies (Gs) 1-5 bid their preferred quantities at prices corresponding to their MPCs or opportunity costs. The stepwise form of the supply curve is typical in electricity markets, because it reflects the varying efficiencies of the production technologies of Gs. The power pool price is set at the intersection of demand and supply curves and equals p4. The shaded area represents the profit earned by Gs 1, 2 and 3 in excess of their MPCs / opportunity costs, thus the residual available to cover their fixed costs and return on investment. Gs 1-3 are infra-marginal generators while G4 is the marginal generator setting the price.

Real Scarcity vs. Exercise of Market Power

The key to efficient markets is that market prices reflect the relative scarcity or plentitude of resources at all times. Therefore, the markets should allow true price signals to emerge and, in scarcity situations, the prices should be based on the value of incremental supplies when this is higher than the highest available bid (Wilson, 2000). This price setting mechanism can cause significant price spikes (sometimes called scarcity rents) at times, but they are sometimes necessary to ensure reliability in tight supply conditions. Also, in the long run, scarcity rents enable greater contributions to fixed costs and profits of the generators and induce more generators in the markets when the supply falls below demand. In theory, this mechanism should result in equilibrium, where the levelized average spot price equals the long-run marginal cost (LRMC, including competitive rate of return) per unit of marginal capacity addition of the market (Hughes and Parece, 2002; 32-33). In this case, price spikes are actually "quasi rents" rather than "scarcity rents", since when incorporating the fixed costs and return on investment in the price residual over MPC, the costs converge the price. In equilibrium, markets are also sustainable in a sense that the efficient prices give producers incentives to invest in new capacity, entry is unconstrained and there is no overcapacity bringing down prices.

In practice, real scarcity is often hard to distinguish from exercise of market power, since when supplies are tight, preconditions for *physical withholding* and *economic withholding* are much more favorable and thus such withholding occurs more often. These two ways to exercise market power impede the efficient functioning of wholesale electricity markets – in physical withholding a generator withholds some available output by not bidding it to the market, and in economic withholding a generator bids some output at price exceeding its MPC.

Figure 19 presents the both situations when the power price spikes above the MPC – a competitive case, when the price reflects real scarcity, and an uncompetitive case, when the price reflects the exercise market power (physical or economic withholding).

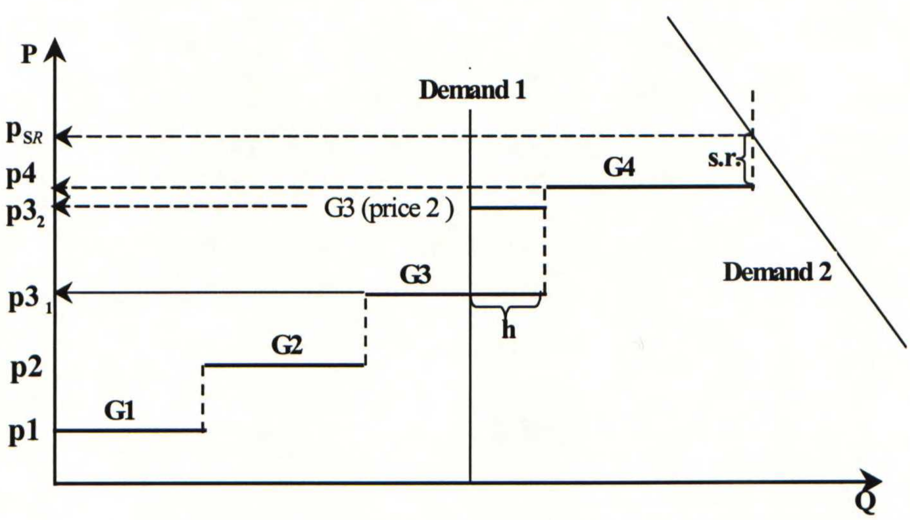

Figure 19 **A demonstration of a real scarcity situation and an exercise of market power in deregulated power markets.**

In the "base-case" situation the generating companies (Gs) 1-4 bid their preferred quantities at prices corresponding to their MPCs or opportunity costs. The power pool price is set at the intersection of Demand 1. and the supply curve, and equals $p3_1$. A true scarcity situation is depicted where Demand 2. intersects the supply curve, a scarcity rent (s.r.) is created and the resulting price is p_{SR}.. The scarcity rent occurs because the value of incremental supply is higher than the highest available bid (G4's bid). An exercise of market power occurs due to G3's activities. Physical withholding appears when G3 withholds amount h from the market and the resulting price is p4, when G4 becomes the marginal supplier. Economic withholding appears when G3 raises its bid at a level [G3 (price2] slightly below G4's bid and the resulting price is $p3_2$.

Figure 19 demonstrates the scarcity rents (s.r.) earned by all generators, when a tight situation calls for price exceeding the highest available bid. This mechanism ensures adequate price signals in physically efficient markets. Figure 19 also presents that when the market is tight and demand inelastic (Demand 1-curve is vertical), one single producer can cause the whole system price to rise above the competitive level. Specifically, this physical withholding occurs when generator 3 holds back amount h, generator 4 becomes the marginal bidder determining the price, and generator 3 gets this price (p4) for the residual quantity bid into the market[37]. When generator 3 realizes that it is the marginal bidder and raises its price to slightly lower level than generator 4's bid price, economic withholding occurs and generator 3 is able to receive a higher price ($p3_2$) for all of its output. In this case, consumers are worse off by the amount that generator 3 is better off. If the total quantity demanded is affected by the higher price, consumers and generators jointly bear the losses resulting from the reduction of sales accompanying the price increase (Reitzes et.al., 2000; 16).

Market power involving physical and economic withholding can be attributed to *horizontal* market power, which most often results from oligopolistic or collusive generator behavior. Skytte (1999, 28-30) identifies two other types of market power: *vertical* and *spatial*. Vertical market power occurs when one single firm holds control over more than one aspect of the electricity value chain, which can potentially give the firm unfair competitive advantage by allowing cross-subsidizing. Spatial market power appears most likely in situations when there are bottlenecks in the transmission network and one power generator is able to become a dominant supplier in a particular geographic area by making strategic bids to make the bottleneck binding. This process causes the system and area prices to diverge. However, the divergence can also be a result of simple system constraints and thus inefficiency in the transmission grid.

Exercise of market power reduces substantially the efficiency of markets, but there are at least two ways to curtail its consequences. First, price caps can restrain the exercise of market power. Namely, if the price cap is set above the competitive level, but below the price that would result without the cap, the spot prices will lower and the aggregate output bid in the market will increase (Carlton and Perloff, 1994; 864-870). Second, long-term contracts impact spot prices in the short run to the extent that they impair the exercise of market power. Specifically, if a generator has sold much of its output under forward contracts, it will have much less incentive to restrict its output or inflate the bid price

[37] It is important for generator 3 to make sure that the profit gained from the lower amount of power bid into the market is higher than the profit gained without the withholding.

since it will have a smaller infra-marginal quantity on which to collect the resulting higher price. Therefore, the incentive of a generating company to exercise market power will depend on its net purchasing position in the market in a given time (Borenstein, 2001).

4.3.2 Trading efficiency

Marshall (1920) argues that "a market" is an area over which prices tend toward equality. Indeed, California and Finland could in theory represent such markets, since the commodity can be transferred in large amounts at a low cost within the area. However, while Finland constitutes a market having its own area price, California market has several physical alternative venues to trade power (the PX day-ahead and day-of markets, the ISO real-time market as well as the day-ahead and hour-ahead ancillary services markets). All California markets are practically substitutes to each other, since they all trade the same commodity, supplied at the same time in the same location. So, bidders should be quite indifferent between decisions to bid into one of them. Arbitrage's effect is to bring prices to fundamental values and to keep markets efficient (Shleifer and Vishny, 1997). Hence, rational, profit-maximizing bidding behavior should result in nonexistent arbitrage opportunities, price convergence, and efficient markets in respect of trading. Since prices sometimes differ also in various geographical areas within one electrically interconnected area (such as California or the Nordic region), due to congestion or bottlenecks in the grid, potential arbitrage opportunities can exist. If the difference between the area prices exceed the cost of relieving the congestion, spatial market power could be exercised.

In practice, inefficient price formation and arbitrage opportunities tend to appear easily between markets, due to transaction costs within and between the markets, risk aversion and a learning effect (Borenstein et.al., 2001). Risk aversion denotes in this context that, in the absence of large number of risk-neutral buyers or sellers, a significant number of risk-averse buyers can differentiate the day-ahead price from the real-time price if they want to mitigate their risk exposure by concentrating their purchases on a longer-term day-ahead market. The learning effect refers to inefficient pricing occurring in the period subsequent to the market formation. Thus, in any new market, it usually takes time for traders to learn about the market rules, distribution and behavior of prices and the market fundamentals, before they can start taking greater advantage of the arbitrage opportunities. Until that time, arbitrage will exist.

The concept of opportunity cost relates closely to the trading efficiency of electricity. In particular, arbitrage often originates from the opportunity costs of revenue foregone by committing to another market. More specifically, a generator will not rationally bid into any of the markets at marginal cost, but instead at the equilibrium expected price prevailing in an alternative market, i.e. the opportunity cost. This process effectively makes sure that prices do not converge to a single value among the venues, potentially due to the loss of option value on commitments made early and the relative premium required on such earlier transactions (Michaels and Quan, 2002).

4.4 Welfare Gains and Transfers in Deregulated Power Markets

Due to the immense size of the power industry, even small amounts of market power can potentially cause huge wealth transfers from consumers to generators. However, in the absence of market power, benefits will potentially come down to consumers in the form of lower retail prices deriving from better investments decisions and more diverse mix of energy products due to increased innovation brought by a more robust competition. Namely, in deregulated power markets, free entry of new producers encourage existing ones to seek innovative and more efficient production and system technologies to survive.

One problem of electricity market regulation and monopoly pricing is that they do not result in welfare transfers or gains. Thus, a major objective of power market deregulation is to improve (or rather to optimize) the overall welfare of the society, in respect of both consumers and producers. Namely, one of the most prevalent beliefs of the outcomes of deregulation is that the wholesale price that results in competitive markets will be below the price that would prevail under regulation.

Pricing mechanisms in competitive markets will compensate for efficient production technologies since the power produced with lower-cost methods will gain a higher margin over the MPC than it would under regulation (in which the price is based in the average cost). This is a consequence in "uniform-price auctions", like those in California PX and Nord Pool, where the actors have every incentive to bid competitively. Namely, if a producer loses its competitive bid (based on its marginal opportunity costs) due to others participants' underbidding it, it will still be better off, due to not committing itself to sales at prices that fail to cover its average costs (Cramton et.al., 2002). Conversely, if its bid is accepted, the price cannot even in the worst case be less than its MPC, which will cover the incremental cost of producing the power. To sum up, in uniform-price auctions, the price should in theory and on average be lower than in regulated markets, which will eventually increase the overall welfare of the society. This happens when consumers' welfare increases due to lower prices, partly at the expense of reduced profits of producers (due to lost monopoly rents) and the diminished market shares.

According to the theory of free markets, all kinds of government intervention are considered hazardous to the competitive price formation and overall welfare. However, such measures as setting price caps and arbitrarily taxing the product can potentially impede the market functionality. The California reform included freezing the retail prices, which precluded fluctuating wholesale prices to migrate into retail rates and caused welfare transfers contingent to wholesale price movements. While the fixed rates provided price insurance for consumers against price spikes, they also prevented them from receiving the benefits of lower wholesale prices. As for utilities, the frozen rates supported the process of covering the stranded costs in case wholesale prices were far below the frozen retail rates but if above the retail rates, in worst case lead to heavy losses. Also the wholesale caps set by the FERC caused similar welfare transfers between consumers and utilities.

When deregulating power markets, the tax issue often also emerges. In particular, taxation can work as a tool to optimize the distribution of welfare gains. Lehto (1995; 47-48) argues that excessive profits sometimes gained by the producers (due to limitations of competition) could be channeled to power consumers by lowering the value-added tax of electricity. Thus, welfare would be redistributed and the cut in value-added tax financed by using a "fiscal tax". Fiscal tax would not lower power consumption, since it would not increase the price of the least efficient producer, or increase the wholesale price, but it would seriously fight against the spirit of free markets, which might explain why it has not been widely used in practice. Figure 20 depicts the theoretical and real channels of welfare transfers in deregulated electricity markets.

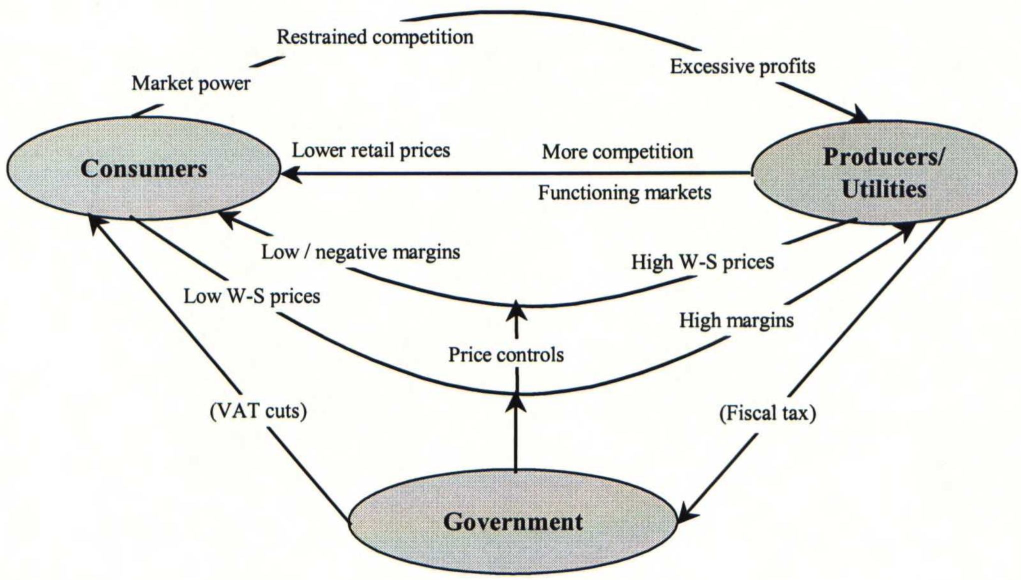

Figure 20 **Different theoretical and real channels for welfare transfers and gains in deregulated electric power markets.**

Consumers can gain welfare from producers/utilities through diminished prices and insurance against excessive wholesale (W-S) prices migrating into retail prices and from government directly with VAT-cuts and indirectly through having price caps (retail rate freeze and W-S price caps). Producers/utilities can gain welfare from consumers through excessive profits by exercising market power and high margins over the frozen retail price, in case of low W-S prices, and from government indirectly through facing the wholesale caps. Government can gain welfare from producers through fiscal taxes.

5 ANALYSIS OF SUCCESS - USING WHOLESALE PRICE INDICATOR

Borenstein and Bushnell (2000; 1) state that the gains from restructuring the electricity markets are most likely to occur through improvement in the efficiency and prudence of long-term investments, but these benefits will be very difficult to measure. They also emphasize the role of exercise of market power in lessening the favorable effects of restructuring in a short run. Thus, there seems to be certain limitations in making absolute inferences from the historical short-term data of newly generated deregulated power markets. It could therefore seem somewhat more plausible to make comparisons between two markets and the success gained during the first years of operation, while still keeping in mind the limitations incorporated in analyzing the success quantitatively.

5.1 Wholesale Market Mechanisms

Wholesale electricity can be traded with bilateral contracts, in official mandatory or voluntary power exchanges and in private pools. Official power pools were created in consequence of deregulation and the prices quoted there in general reflect the outcomes of deregulation quite well. Namely, the prices act as transparent yardsticks of competitiveness and efficiency of the markets, reflect the dynamics of overall market conditions while still give the best economic signals for entry and exit decisions. Therefore, for the purposes of this study, the analysis of power exchange prices is the most meaningful. To understand the price formation in both markets (California and Finland), a brief introduction to the fundamentals of the power exchanges, the power scheduling arrangements and the handling of transmission in respective markets is of importance.

The power exchanges in California (PX) and Finland (Nord Pool) have a few similarities: both are single-price auctions, incorporate supply and demand bidding as well as continuous trading. Most of the power transactions in California are concentrated in the PX (roughly 80% of electricity actually delivered is traded in the PX day-ahead forward market) but some volume is also traded in the real-time imbalance and ancillary services (A/S) markets administered by the ISO. In Finland, official power trading started in August 16, 1996 when the Finnish Securities and Derivatives Exchange Ltd. established EL-EX, a continuously traded bid-offer exchange market. In 1998 Fingrid bought EL-EX, sold half of it to Svenska Kraftnät and the exchange was subsequently integrated into Nord Pool (Hämäläinen, 1998). Since June 15, 1998, Nord Pool has provided a spot and derivatives market for Finnish and cross-border power transactions as well as a benchmark price for domestic power contracts.

The PX commenced its operations in April 1, 1998, when the AB 1890 took effect. The PX operates two energy markets, a day-ahead market and a day-of market[38]. In the day-ahead market, PX participants submit every morning by 7:00 a.m. portfolio bids to buy and sell energy for each hour of the succeeding day, from which the PX derives unconstrained statewide price and quantity for each hour. The day-of market works as a market where the participants can modify their day-ahead

[38] The day-of energy market was first (July 1998-January 1999) called "an hour-head market", which incorporated hourly auctions, instead of three auctions per day in the day-of market. The name and the auction practice was changed due to extensively thin trading in the hour-head market.

positions. The PX, acting as a scheduling coordinator (SC), submits its balanced day-ahead supply-demand schedules every morning to the ISO, which derives zonal prices (NP15, ZP26 and SP15[39]), in case of intra-state congestion, and calculates congestion usage charge rates. If there is no congestion, the unconstrained price and quantity pairs work as final schedules.

In addition to the congestion management market, the ISO operates real-time imbalance as well as day-ahead and hour-ahead A/S markets. In the imbalance market, the ISO balances loads and resources in real time by incrementing and decrementing resources as needed to maintain a system-wide reliability. The real-time price is used to settle deviations between scheduled and actual quantities of supply and demand and is derived from supplemental energy bids, provided as late as 45 minutes prior to the dispatch hour, and energy bids submitted in conjunction with the A/S capacity bids (Michaels and Quan, 2001).

The A/S market comprises four "capacity-only" day-ahead and hour-ahead zonal auctions: Regulation, Spinning Reserves, Non-Spinning Reserves and Replacement Reserves. Yet, bidders must also submit an energy bid in conjunction with the capacity bid, to determine whether they are called to provide the bid capacity (Bohn et.al. 1999). Due to its bipartite nature, the A/S market resembles an option market. The capacity bid (reserve capacity held by the ISO to buffer contingent system imbalances) represents the option held by the ISO to call energy in a few minutes notice, the capacity price ($/MW) quoted in the A/S market equals the option premium, the reserve itself is the underlying asset and the real-time energy price received by the supplier, in case it is called, equals the strike price. The real derivatives market in the PX, called the Block-Forward market, was never widely used due to the CPUC's orders to restrict the IOUs to schedule forward. Therefore, almost all the power traded in the PX was scheduled to the day-ahead market.

The Nord Pool Elspot market follows the same main principles as the PX day-ahead energy market, except that it is a non-mandatory exchange. The Eltermin market is a derivatives market for Nordic power, which offers futures and forward contracts of various maturities. The fact that 112TWh was traded in Elspot in 2001 whereas the same figures were 910TWh and 2,769TWh for futures and OTC-

[39] California has a total of 24 price zones, but most of the time congestion occurs only in two transmission paths, resulting in only three different zonal prices.

contracts, respectively, reflect the relative magnitude of the Eltermin market (Nordpool ASA, Annual Report 2001). The Elspot exchange calculates on a daily basis an unconstrained *system price* for the whole Nordic region based on aggregate supply and demand bids for every hour of the following day. The Nordic market is divided into 6 plus price zones, Sweden, Finland, Western and Eastern Denmark and 2 plus zones in Norway, within which the price is uniform. In case of capacity limits between the price zones, *area prices* are calculated for the congested zones. The price difference between the system price and each area price equals the capacity fee paid by the national grid companies. Basically, the system price and the area price differ from each other in a sense that the former has a financial role in working as a Nordic-wide reference price for derivatives contracts while the latter holds an operational role in giving price signals for the respective areas' production planning (Houmöller, 2000). Figure 21 illustrates the area pricing mechanism and formation of the capacity fee in Nord Pool.

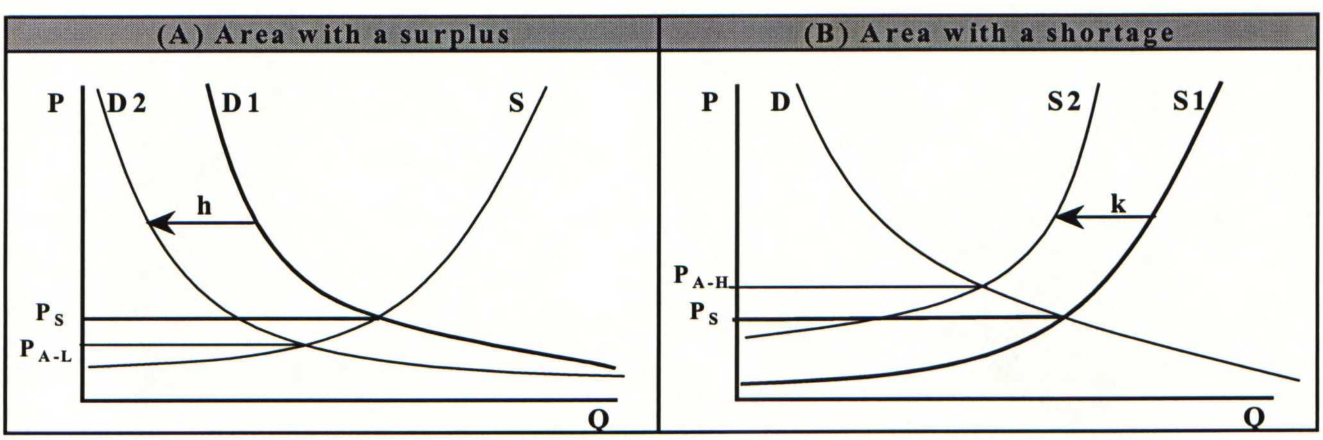

Figure 21 **The inter-zonal congestion management mechanism in Nord Pool in case of deficit and excess capacity [revised from Haumöller (2000; Figure 3.5; 59)].**

Panel A represents a case, in which there is surplus electricity in the transmission line between two zones. P_{A-L} is 'a low area price', which results from congestion management administered by Nord Pool. Nord Pool purchases amount h, which lowers the price in relation to the system price P_S, and thus stimulates higher purchases and lower sales in the surplus area. Panel B represents a case, in which there is shortage of electricity in the transmission line between two zones. P_{A-H} is 'a high area price', which results from congestion management administered by Nord Pool. Nord Pool sells amount k, which increases the price in relation to the system price P_S and thus stimulates higher sales and lower purchases in the shortage area.

Figure 21 illustrates the congestion management operations of Nord Pool. By adjusting the system price with additional purchases and sales, Nord Pool effectively releases bottlenecks between zones.

By crediting the participants who relieve the congestion and debiting those who strain it, it also induces the participants to contribute to the management.

Fingrid Plc. operates its own regulation or balancing market and trades with other Nordic system operators to create an integrated network of imbalance arrangements (Henney and Russell, 2000). National system operators handle intra-zonal delivery constraints within their respective price zones. In the Finnish price zone, Fingrid manages the bottlenecks by operating regulation-up and regulation-down power markets (read more in Henney and Russell, 2000, 39-40).

Table 2 lists the market facilitators, the main power markets and some information on the pricing zones and derivatives markets in California and Finnish electricity markets.

	CALIFORNIA	FINLAND
Market facilitators The markets operated	**California Power Exchange (PX)** (1) Forward day-ahead energy market (2) Day-of energy market	**Nord Pool (1998 -)** (1) Elspot (day-ahead market) (2) Eltermin (futures market), duration up to 6 months (3) Inter-zonal congestion management
	Independent system operator (ISO) (1) Real-time imbalance market (2) Day-ahead and hour-ahead A/S market (3) Transmission congestion market	**Fingrid Plc.** (1) Regulation or balancing market Market for managing intra-zonal congestion
Zonal prices	NP15 (North) ZP26 (Center) SP15 (South)	System price (unconstrained price for the Nordic region) Area price for Finland (Finland is a single price zone in N/P)
Derivatives market	Very thin market operated by the PX	Robust and liquid market operated by the Nord Pool

Table 2 **The market facilitators, the markets operated, zonal prices and description of the derivatives markets in California and Finnish electricity markets.**

5.2 Literature Review

Research of power market deregulation, its outcomes and implications for the efficiency has for the most part concentrated on exploring the existence of market power and monopolistic behavior of market participants. Therefore, only little notice has been laid on deregulation's impacts on welfare gains and transfers. Due to the recent crisis in California power markets in 2000-2001, the underlying causes of the crisis and the overall market design in California have drawn a lot of attention in the academic world. The market power issue has been extensively documented, even though it appears to be very difficult to distinguish market power from simple scarcity situations. The Nordic power market and Nord Pool have been emphasized mostly in a benchmarking context as a well working market for electricity trading. Therefore, the market power issue has not been highly stressed, nor the market efficiency questioned. In this chapter, a brief review to the existing literature related to deregulation of wholesale electricity prices, market efficiency and welfare gains is provided.

Physical efficiency of electricity markets is often investigated by identifying potential for exercise of market power. The analysis is usually conducted with simulating competitive benchmark prices and comparing them with actual or assumed market prices. A game theory approach of analyzing the behavior of oligopolistic generators in a simulated non-cooperative game framework is a frequently used approach when investigating the market power issue. Bulk of the studies have used a *Cournot model*, which simulates "oligopolistic prices" based on assumptions that markets are price sensitive, larger generators have more incentive to exercise market power than smaller ones and producers take the rivals' output choices as given (Reitzes et.al., 2000). The simulated prices are then compared to the competitive prices to determine the effect of market power.

Borenstein (1999) reports that the exercise of market power in California electricity market is highly likely during high load periods, and calculates Cournot prices, which exceed the competitive prices by as much as 400% during a 35,000 MWh load period[40]. Sulamaa (2001) identifies potential for exercise of market power in Finnish markets and reports Cournot prices 37% and 23% in excess of competitive prices in case of no cross-border trade and cross-border trade, respectively. Kopsakangas-Savolainen (2002) comes to similar results in analyzing the implications of deregulation for wholesale prices. She reports Cournot mark-ups of 114.9% when comparing the Cournot prices to prices prevailing before deregulation took place.

Trading efficiency of electricity markets has not been well documented in either California or Finnish power markets. Borenstein et.al. (2001) explore the interaction between the PX day-ahead and the ISO real-time market and the level of price convergence between the markets. They identify significant

[40] Other papers handling the market power issue in California markets include e.g. the papers of Silsbee and Jurewitz (2001), Borenstein, et.al. (2000), Harvey and Hogan (2001) and Joskow and Kahn's (2002) extensive and well recognized paper, which covers a competitive benchmark price analysis and capacity analysis.

and persistent price differences in the sample period of April 1, 1998 through November 30, 2001. Also, they discover that some risky arbitrage strategies appear to have a positive expected return. Sharpe Ratio for weekly trading rule of capturing the price differences in the two consecutive markets equal 0,8 on average, while the same ratio for S&P 500 is –0.09. Bohn et.al. (1999), Siddiqui et.al. (2000) and Earle et.al. (1999) discuss the operations of A/S markets and identify clear inefficiencies and thus arbitrage opportunities between trading in the PX day-ahead market and the A/S markets. In particular, Bohn et.al. (1999) find that producers can on average earn extra $248 / MWh if choosing to bid into the A/S market instead of the PX market, and if called to produce. In practice, the A/S price (the option price) and the real time ISO energy price (the exercise price) are together worth $248 more than the PX price. Conversely, Earle et.al. (1999) examine the time period from April 1998 through March 1999 and find that the strategy of bidding into the PX day-ahead market yields higher profits than that of bidding into the A/S market.

Arild and Halseth (2000) emphasize the high concentration of production capacity in Nordic markets (with six largest producers controlling more than 60% of production) and the open trade between the countries. They use ECON's numerical electricity market model to estimate the impact of trade on prices and welfare. They find some potential for exercise of market power, convergence of zonal prices under free competition and quite significant welfare gains due to open trade. They argue that the net welfare gains (increase in consumer surplus – reduction in producer surplus – import costs) total NOK 500 Million and NOK 3.6 Billion for Finland and the Nordic market in total, respectively. Halseth (1998) uses the same ECON's model to examine the effect of removing cross-border protective regulations (border tariffs) on simulated market prices at all the Nordic inter-connectors. Although he discovers that Nordic area prices converge when the tariffs are removed, the Finnish area prices tend to increase slightly due to the free trade. He interprets this controversy as increased net exports and domestic production in Finland, which is a consequence of increased base-load exports to Sweden, while imports from Sweden stay constant due to increased bottlenecks in the border.

5.3 Sample Data

Since the purpose of the quantitative empirical section of this study is to analyze the success of the electric power deregulation in California and Finland, using the wholesale price indicator, the price data are the most essential in this respect. Therefore, the core part of the sample data encompasses hourly price quotations in California and Finnish electricity wholesale spot markets.

As for California, hourly wholesale price data are available for a period April 1, 1998 – January 31, 2001 - from the date the PX started operations till the date the trading in the PX was closed down, due to its bankruptcy. The data consist of unconstrained PX day-ahead price quotations, zonal day-ahead prices for zones SP15 and NP15, zonal ISO real-time imbalance prices for zones SP15 and NP15, and zonal day-ahead and hour-ahead A/S prices for zones SP15 and NP15 for Regulation, Spinning Reserves, Non-Spinning Reserves and Replacement Reserves. I have obtained the California price data from the University of California Energy Institute. As for Finland, hourly wholesale price data are available for a period June 15, 1998 – October 15, 2002 – from the date Finland became a part of Elspot in Nord Pool till the present time. The data consist of Nord Pool system price quotations and area prices for the Finnish price zone. I have obtained the Finnish data from EL-EX (Ville Pesonen).

As shown previously in the study, the nature of electricity and the behavior of electricity prices differ exceedingly from that of other commodities and equities. Consequently, to analyze the power market prices, some additional data are needed to illustrate these special characteristics of electricity.

As for California, hourly supplemental data for a period April 1, 1998 – January 31, 2001 are available. The data encompass hourly quantity quotations in the PX for unconstrained system, day-ahead and hour-ahead quantity quotations for A/S (Regulation, Spinning Reserves, Non-Spinning Reserves and Replacement Reserves), real-time system wide demand quotations, and hour-ahead and day-ahead system wide exports and imports. Additionally, weekly prices of natural gas delivered to California utilities are available. I have obtained the data from the University of California Energy Institute. As for Finland, weekly supplemental data for a period June 1, 1998 – December 31, 2001 are available. The data comprise absolute and percentage water reservoir levels in Norway and Sweden [obtained from Helsingin Energia (Harri Mattila/Heli Vilkki)], generation and demand quantities for the Nordic region, generation (by technique), consumption and imports and exports of Finland (obtained from NORDEL and www.energia.fi).

Due to the distorting effects of the California electricity crisis from May 2000 through January 2001 on prices, I have at times excluded that data set from the analysis. However, it is an important and interesting time period to analyze, which is why I have occasionally provided results from both the whole dataset and the data excluding the crisis period.

5.4 Hypotheses

In the course of the study two main objectives of deregulation have been discussed and analyzed – efficiency and welfare gains. Most naturally, these two themes serve as a basis for the hypotheses as well.

5.4.1 Efficiency Hypotheses

California electricity market deregulation differed substantially from that of Finland. The Finnish reform followed for the most part the core ideas of deregulation – elimination of extensive government control and creation of markets free from unnecessary rules and regulations. Due to the political controversy and strong opposition from various interest groups, California needed "heavy-handed" deregulatory processes backed by significant compensatory measures to get the deregulatory proposal through. Naturally, this process generated a situation far from ideal to face the free markets and support the emerging competition. Finland, on the other hand took "lighter-handed" approach to deregulation, which provided good foundations for successful market mechanisms. Consequently, I have a reason to hypothesize that California deregulatory reform had poorer preconditions to create efficient wholesale markets than the Finnish one.

H1: Finnish wholesale markets are more efficient than California wholesale markets.

Occasional volatility and price spikes can occur in efficient electricity markets, and are healthy if they reflect temporary scarcity. However, extreme volatility can be symptomatic of design flaws that inhibit, rather than promote, competition and risk justified wealth transfers (Siddiqui et.al., 2000; 64) There are certain explicit reasons for the undesirability of extensive volatility in the electricity markets. First, higher, unpredictable and "clustered" volatility is not good for producers and utilities, since such uneasiness is hard to hedge against. Especially in California, the IOUs were extremely vulnerable to excessive price spikes, since the hedging was restricted altogether. Second, if price spikes are caused by abuse of market power, the abusers are the only ones who are able to reap the benefits from such price movements, leaving all other parties to bear the negative financial consequences. Finally, operating in volatile and unpredictable markets is far riskier than in stable and easily forecasted markets. Thus, market efficiency means in this respect less risky, more predictable and better market environment for most of the participants.

Autocorrelation refers to the "memory of prices". If autocorrelation does not decline in line with increased lags, the prices are likely to be more predictable than prices not having such autocorrelation characteristics. Hence, high and persistent autocorrelation implies better predictability, forecasting ability and ultimately lesser risks to manage positions.

To bundle the above arguments together, I come up with the following sub-hypothesis of H1, which is tested with the three propositions.

H1A: Risk profile of prices in California electricity markets is higher than that in Finland.

Proposition 1: *Volatility is higher in California than in Finnish electricity markets.*

Proposition 2: *Autocorrelation is higher and more persistent in Finnish than in California electricity markets.*

Proposition 3: *Price spikes are larger and more frequent in California than in Finnish electricity markets.*

Previously, the theoretical and practical frameworks for the system and area prices were introduced. In theory, efficient markets should make sure the two prices converge, since bottlenecks in the transmission grid and abuse of spatial market power (causing the divergence) would not exist in efficient markets. However, it is obvious that in practice the two prices do not converge and the gap between them can be fairly wide at times. To put the theory into practice and test the difference between the gaps in California and Finnish markets, I form the following sub-hypothesis of H1, which is tested with the below proposition.

H1B: California electricity markets incorporate more evidence of transmission constraints and spatial market power than Finnish electricity markets.

Proposition: The gap between the system and zonal prices is larger in California than in Finnish electricity markets.

Trading efficiency means that persistent arbitrage opportunities do not exist and therefore prices for the same product, dispatched in the same quantity, place and time have equal prices in consecutive markets. In California wholesale spot markets it was possible to trade the same commodity (MWh of electricity) in two markets within one day (the PX market and the ISO market). In effect, the day-ahead spot price was a day-ahead estimate of the real time price quoted just before the dispatch hour. Trading efficiency also implies that the value of electricity traded day-ahead the dispatch hour should be equal to the capacity set aside in the A/S market plus the probability weighed electricity price if called to produce. In Nord Pool, such mechanism does not exist, since the day-ahead price is subsequently only adjusted for zonal congestion. Therefore, to test trading efficiency, only California markets can be taken into consideration. I come up with the following sub-hypothesis of H1, which is tested with the two propositions.

H1C: California electricity markets evidence trading inefficiency.

Proposition 1: The day-ahead and real-time prices diverge in California markets.

Proposition 2: The day-ahead and A/S price plus the probability-weighed ISO price diverge in California markets.

5.4.2 Welfare Hypotheses

One of the general objectives of deregulation (discussed in chapter 2.3) was *welfare*, which means that if successful, deregulation should result in enhanced overall social welfare level. It is also generally believed that the power consumers will gain bulk of the welfare gains during the process. In contrary, the welfare of utilities and producers can decrease somewhat due to the breach of the regulatory contract (which is why the utilities in California were compensated with the competition transition charge embedded in frozen retail price) (see e.g. Sidak and Spulber, 1998; 179). Therefore, I form the following hypotheses.

H2: Consumers have gained welfare; spot prices have declined on average.

H3: Power producers / utilities have lost welfare.

5.5 Methodology

The methodology of the study is both statistical and descriptive. In particular, I will test the efficiency hypothesis merely with statistical methods, whereas testing of the welfare hypothesis encompasses both quantitative analysis and descriptive reasoning based on numerical data. Since the aim of the quantitative empirical part of the study is to explore the wholesale power markets (reflecting the outcomes of deregulation) as well as contrast the two set of results from both markets to each other, I will use both absolute and relative statistical methods.

5.5.1 Tests for Market Efficiency

I will use the normal volatility metrics, hourly and daily log-volatilities (following Deb et.al., 2000) and hourly coefficients of variation, COVs (following Sidduqui et.al., 2000) when measuring and comparing the price variations in the both markets. Standard deviation metric may not be an effective tool for comparing price volatilities since it is not unit free. Therefore, I will also use the COVs and log-volatilities in the analysis. These two statistics also take better into account the special characteristics of electricity (e.g. autocorrelation and the volatility clustering features). COV is simply measured by dividing the normal standard deviation over a specified period with the sample mean. Log-volatility is calculated as follows.

$$\sigma_{\log} = \sqrt{\frac{n\sum_{i=1}^{n}\left(\log\frac{P_{i+1}}{P_i}\right)^2 - \left[\sum_{i=1}^{n}\left(\log\frac{P_{i+1}}{P_i}\right)\right]^2}{n(n-1)}} \tag{4}$$

where $\sigma_{\log}$ denotes log-volatility, n is the number of observations, i.e. the hours, i is the hour in question and P equals the price. I will use Equation 4 when measuring daily volatilities, as well. In that case, the observations represent logarithms of daily averages of hourly prices in relation to previous day's equivalent averages.

I will use F-tests to test the differences in variances of prices in California and Finland. To support the volatility analysis and to compare the distributional properties of the markets to each other, I will draw some price histograms and price duration-curves from both sets of data (California and Finland).

I will do several runs of autocorrelation calculations with increasing lags. Also, I will run the same simulations with squared prices to test the robustness and persistence of the autocorrelations. I will compare the daily, weekly and monthly average autocorrelations in California and Finnish markets with the correlation coefficient-tests of independent samples.

I will test the magnitude of price spikes in California and Finnish markets by comparing the intra-day price behavior to each other. Particularly, I will compare the differences between minimum and maximum and average and maximum intra-day hourly prices as well as maximum logarithmic price spikes to each other. Moreover, I will test the frequency of price spikes in California and Finland by comparing the percentages of days and hours when the price spikes exceed in percentage and logarithmic scale a certain threshold. I will use t-statistics for testing the differences in magnitude of price spikes and ratio test z-statistics for testing the frequency of price spikes in California and Finnish markets.

I will first test the differences between system and area prices separately in both markets. I will use a t-test for paired two sample means to test the price convergence/divergence. I will test the differences of system and area prices between the markets with a student's t-test of unknown and unequal variances. To make the California and Finnish samples unit free, I will derive a percentage difference between the system and area prices and test whether this difference is higher in California power markets than it is in Finnish markets. Thus, I will formulate the following metrics, which is hypothesized to be higher than zero.

$$\left|\frac{P^t_{A-C} - P^t_{S-C}}{P^t_{S-C}}\right| - \left|\frac{P^t_{A-F} - P^t_{S-F}}{P^t_{S-F}}\right| \geq 0 \qquad (5)$$

where P^t_{A-C} equals the area price (or zonal price) in the California sample at time t and P^t_{S-C} equals the system price (or unconstrained price) in the California sample at time t. P^t_{A-F} and P^t_{S-F} equal the Finnish area and system prices at time t, respectively. These relative price differences are hypothesized to be statistically different in the California sample than in the Finnish sample. Finally, I will test the relation between system and area prices with correlation coefficients and regression analyses and test their significance.

I will test the trading efficiency of California markets close to similar way as in the above analysis of system and area prices. Namely, I will test the convergence of the PX and ISO real-time imbalance prices as well as that of the ISO and capacity (A/S) prices with t-tests, OLS-regressions and correlation coefficients.

5.5.2 Tests for Welfare Gains

I will analyse the hypothesized welfare transfers between Finnish consumers and producers and California consumers and utilities graphically and descriptively, rather than statistically. More specifically, I will plot the wholesale prices in California and Finnish markets in a diagram, which enables me to identify the average profits, captured by the Finnish producers and California utilities.

With this analysis, I can compare the gaps between the wholesale price and the frozen retail rate and the "threshold price" in California and Finland, respectively[41].

To test the hypothesized welfare gains of consumers, I will first measure price movements in both markets in nominal terms. Thereafter, to eliminate the demand and resource-dependency biases of electricity prices and to make the price movements in respective markets comparable, I will derive demand as well as natural gas and hydropower-adjusted price changes. The demand adjustment is conducted mathematically as follows:

$$r_{demand-adj.} = \frac{(1+r_t)}{\left(1+\frac{\Delta D}{D}\right)} - 1 \tag{6}$$

where $r_{demand\text{-}adj.}$ equals the demand adjusted percentage price change from the first observation month (April 1998 and June 1998 for California and Finland, respectively) to time t, r_t the nominal percentage price change from the first observation month to time t and $\frac{\Delta D}{D}$ the percentage change in demand from the first observation month to time t.

The resource-dependence adjustment is conducted mathematically with Equations 7 and 8 for California and Finnish wholesale prices, respectively.

$$r_{gas-adj.} = \frac{(1+r_t)}{\left[1+\left(\frac{G_{gas}}{G_{all}}\right)*\frac{\Delta P_{gas}}{P_{gas}}\right]} - 1 \tag{7}$$

where $r_{gas\text{-}adj.}$ equals the natural gas-price adjusted percentage California electricity price change from the first observation month (April 1998) to time t, r_t the nominal percentage price change from the first observation month to time t, G_{gas} the power production from natural gas at time t, G_{all} the total

[41] I thank Doug Grandy (Grandy, 2002) and Harri Mattila (Mattila, 2002) for helping with the methodology.

power production at time t and $\frac{\Delta P_{gas}}{P_{gas}}$ the percentage change in natural gas price in California from the first observation month to time t.

$$r_{hydro-adj.} = \frac{(1+r_t)}{\left[1-\left(\frac{G_{hydro}}{G_{all}}\right)*\frac{\Delta R}{R}\right]}-1 \tag{8}$$

where $r_{hydro\text{-}adj.}$ equals the hydropower adjusted percentage Finnish electricity price change from the first observation month (June 1998) to time t, r_t the nominal percentage price change from the first observation month to time t, G_{hydro} the power production from hydro resources at time t, G_{all} the total power production at time t and $\frac{\Delta R}{R}$ the percentage change in water reservoirs in the Nordic region from the first observation month to time t.

The electricity price adjustment for both demand and resources is calculated by dividing the nominal price change by the product of the denominators in Equations 7 and 8.

Finally, it is worth being aware of the limitations of methodology used in testing the welfare levels in this study. In particular, it can be dangerous to make straight inferences of welfare implications solely based on price data. As a concept, welfare is so diverse that it cannot be explained only in monetary terms. However, since the price data can give at least some information on the trends in welfare levels, the analysis is worth conducting here.

6 RESULTS

In this chapter I will present the results of the quantitative empirical study. I will first provide a brief overview of the core electricity market data in California and Finland. Subsequently, I will introduce and illustrate some main characteristics of electricity prices in California and Finnish markets. In particular, I will present with figures the influence of seasons and raw material conditions on electricity prices. Thereafter, I will introduce and analyze the results of the efficiency tests conducted with the price data from California and Finnish electricity markets. Finally, I will present the results of the welfare gains-analysis.

6.1 Descriptive Statistics of the Sample Data

Table 3 presents some yearly average figures in California and Finnish electricity markets. More specifically, it shows the main price statistics as well as demand, net import and trading data. As for California the data cover the time period April 1, 1998 – December 31, 2000 and for Finland the time period June 15, 1998 - December 31, 2001.

	California			*Finland*			
	1998	*1999*	*2000*	*1998*	*1999*	*2000*	*2001*
Average hourly price*	26.01	28.34	110.42	11.95	13.65	14.88	22.84
Median hourly price	25.00	26.25	60.53	12.01	13.97	14.06	22.52
Standard deviation of hourly prices	19.32	15.74	138.79	4.63	3.83	10.20	8.27
Skewness of hourly prices	3.81	3.57	4.06	1.59	3.09	22.66	9.74
Kurtosis of hourly prices	22.12	24.98	25.74	23.11	38.62	784.35	179.33
Min hourly price	0.00	0.00	6.01	1.33	3.94	2.36	2.02
Max hourly price	190.94	225.00	1500.01	84.40	89.23	476.81	238.01
Average hourly demand (MWh)	25,643	25,958	27,188	8,387	8,881	9,011	9,287
Average hourly net imports (MWh)	N/A	6,476	4,468	1,191	1,324	1,430	1,548
Electricity traded in the exchange**	86%	85%	79%	N/A	N/A	N/A	N/A

* All price quotes for California and Finland are PX day-ahead unconstrained prices ($s) and Nord Pool Finnish area prices (€s), respectively.

** Quantity bid into the PX day-ahead market / Total system load.

Table 3 **Descriptive statistics of day-ahead wholesale prices, hourly demands, net imports and trading volumes in California and Finnish electricity markets.**

Average, median, standard deviation, skewness, kurtosis, minimum and maximum values of hourly prices, average hourly demand, net imports and trading volumes in California and Finnish electricity markets in 1998-2000 and 1998-2001, respectively.

Only a quick look at the price data in Table 3, presented in USDs and EURs for California and Finland[42], respectively, shows the obvious differences between the California and Finnish markets. Namely, the average, median and maximum prices as well as standard deviations are consistently higher in the California sample. The zero minimum prices in the California sample data represent extreme low-demand-periods when thin markets force sellers to bid zero as they want to ensure to be

[42] At the time of writing this study, USD and EUR were approximately in parity.

selected in the auction process. Both samples show clear positive skewness and substantial kurtosis, which is typical for electricity prices.

The demand and net import data show the difference between the sizes of the two markets. In particular, California market is three and four times larger than Finnish market in terms of demand and net imports, respectively. The percentage of power trades channeled through the PX is presented in the last row of the figure. The figures show a declining trend, which can be attributed to increased trading in other venues, such as the real time ISO market.

6.2 Seasonal Properties and Demand and Resource Dependency of Electricity Prices

Electricity prices are highly sensitive to seasonal fluctuations, due to the indirect weather effects and direct effects of varying demand and raw material conditions within a year. More specifically, in California prices usually peak during the late summer and early fall months, whereas in Finland the prices are traditionally persistently higher during the winter months. These differences are mainly attributable to increased consumption due to hotter and colder weather in California and Finnish markets, respectively. Figure 22 depicts the monthly average prices in California and Finland.

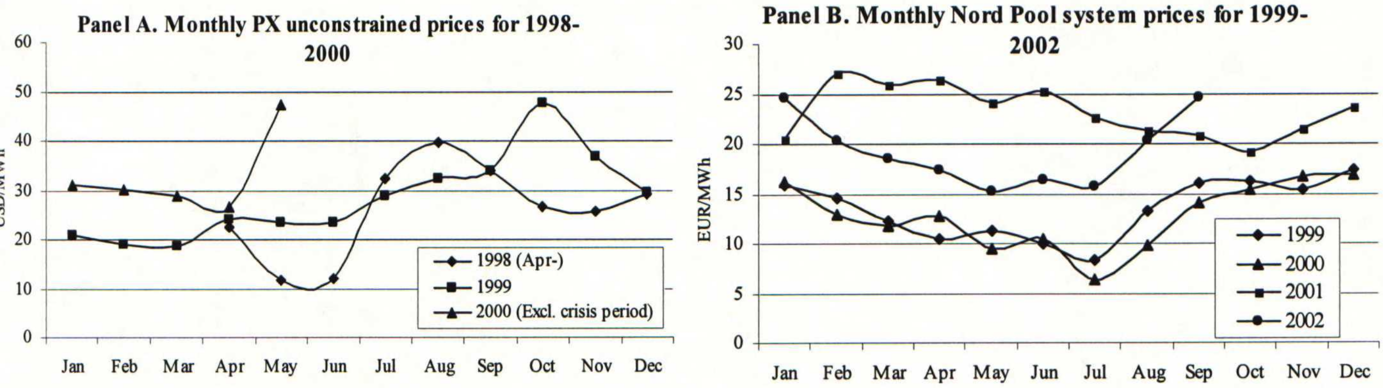

Figure 22 **The monthly average PX prices for 1998-2000 and the Nord Pool prices for 1999-2002.**

In Panel A, monthly average unconstrained day-ahead PX prices in 1998-2000, excluding January-March in 1998 and the crisis period May-December 2000, are presented. In Panel B, monthly average Nord Pool system prices in 1999-2002, excluding October-December 2002, are presented.

Figure 22 evidences seasonal effects, although some yearly variations in the patterns can be detected. Especially in the Finnish sample, prices seem to follow similar paths in every sample year. The California crisis period is excluded from Figure 22, since it would have distorted the scale. Namely, the hourly average price in California in December 2000 was $377 / MWh.

Demand has a major impact on electricity prices. Demand often varies according to seasons and weather, when the seasonal effects transfer into electricity prices through demand. However, it is not always the case, as Figures 23 and 24 show. In those figures the effect of demand on electricity prices is illustrated. Both figures present demand and price over the same period of time, which eliminates the seasonal effects and thus makes the effects of demand clearer. Namely, in Figure 23 the periods from May through August in 1998 (low demand period) and 2000 (high demand period) in California markets are depicted. In Figure 24 the same demand effect is depicted in Finnish markets in February-April in 1999 and 2001.

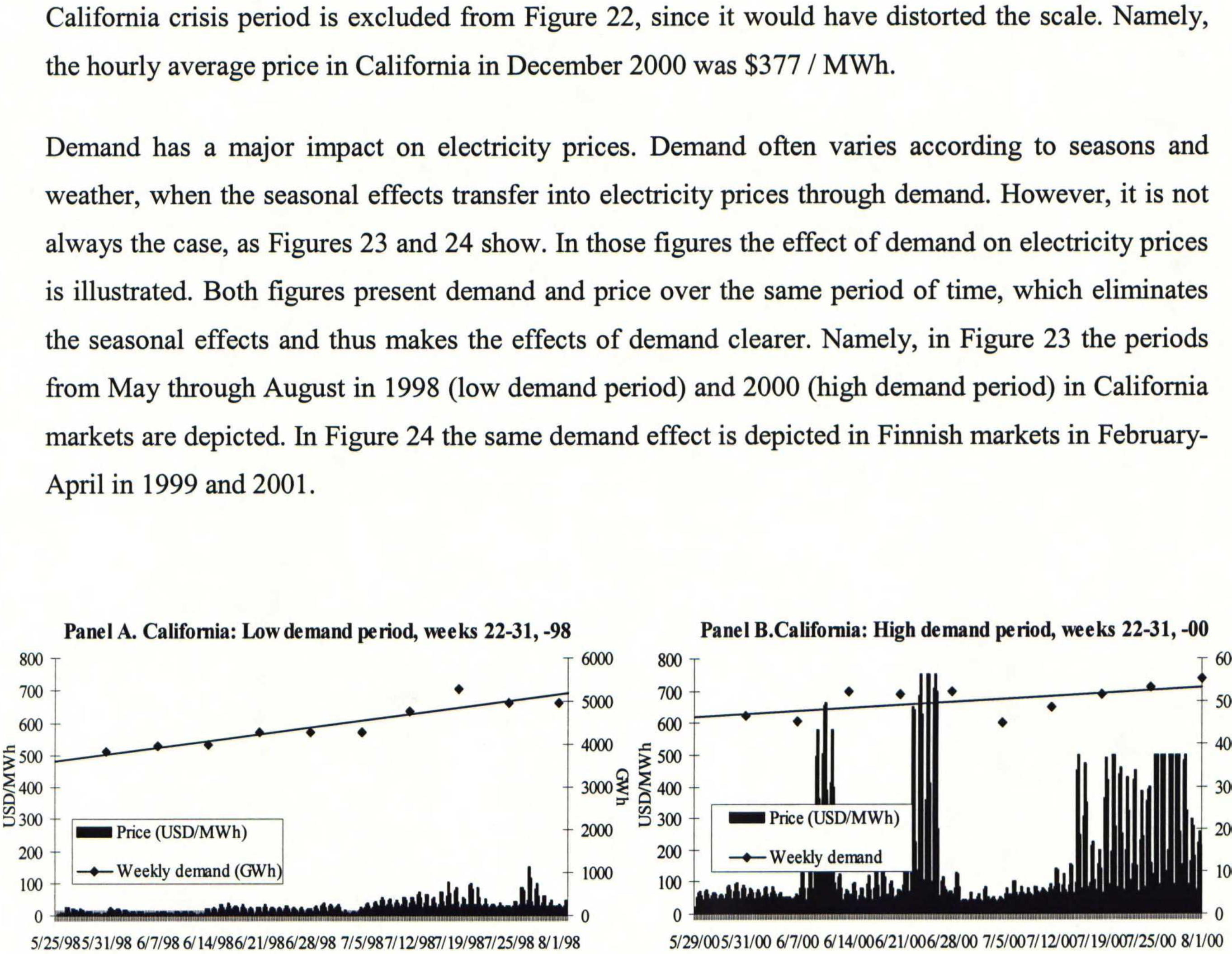

Figure 23 **Prices and demand in California electricity markets in low demand and high demand periods in the corresponding months in 1998 and 2000.**

In Panel A prices (USD/MWh) and weekly demand (GWh) for a low-demand-period in weeks 22-31, 1998 are illustrated. In Panel B prices (USD/MWh) and weekly demand (GWh) for a high-demand-period in weeks 22-31, 2000 are illustrated.

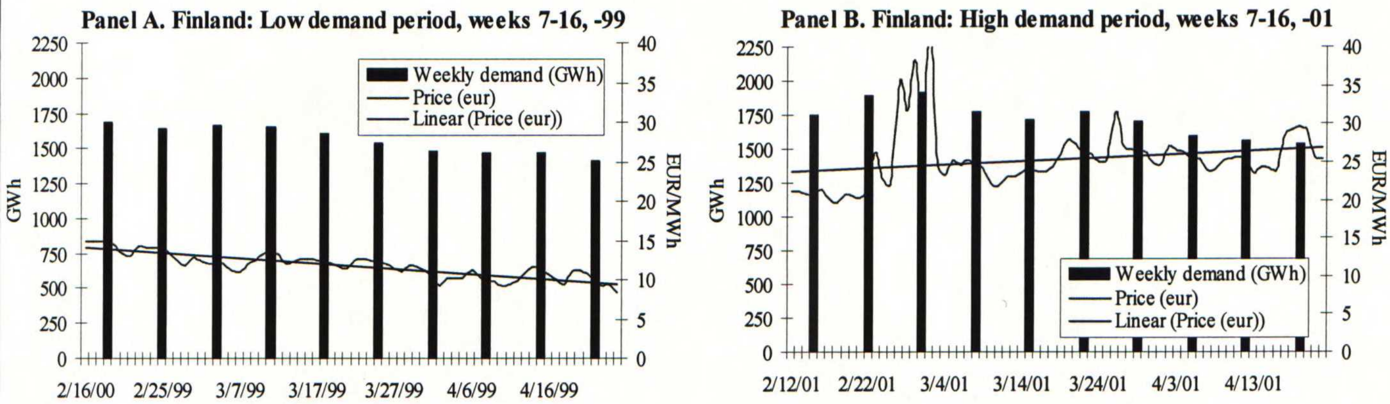

Figure 24 **Prices and demand in Finnish electricity markets in low demand and high demand periods in the corresponding months in 1999 and 2001.**

In Panel A prices (EUR/MWh) and weekly demand (GWh) for a low-demand-period in weeks 7-16, 1999 are illustrated. In Panel B prices (EUR/MWh) and weekly demand (GWh) for a high-demand-period in weeks 7-16, 2001 are illustrated.

The other major determinant in setting electricity prices is the conditions of the major raw materials used in production. In California natural gas prices usually determine the wholesale price, especially during scarce supply conditions. In particular, since natural gas generators are often the most costly and inefficient ones to operate, and often start operating only during the peaking demand periods, they work as the marginal units in the bidding curve and thus determine the final peak period price. In Finland the water reservoirs in Norway and Sweden have the largest impact on electricity prices, but their effects transfer into power prices in a different way than natural gas prices in California. Namely, unlike natural gas, hydropower is often the most cost-efficient power source and thus works as base power rather than peaking power. The effect of water conditions on prices stems simply from the fact that most of the Nordic power is generated from hydro reserves, which are accordingly taken into the supply curve first.

Figure 25 illustrates the impact of water reservoirs on electricity prices during the same period (weeks 33-42) in 1998 and 2002. The effect of natural gas prices in California works in a similar way as hydro conditions in the Nordic countries – scarce (ample) gas conditions boost (lower) the cost of natural gas condensed power and the effect transfers into the power prices.

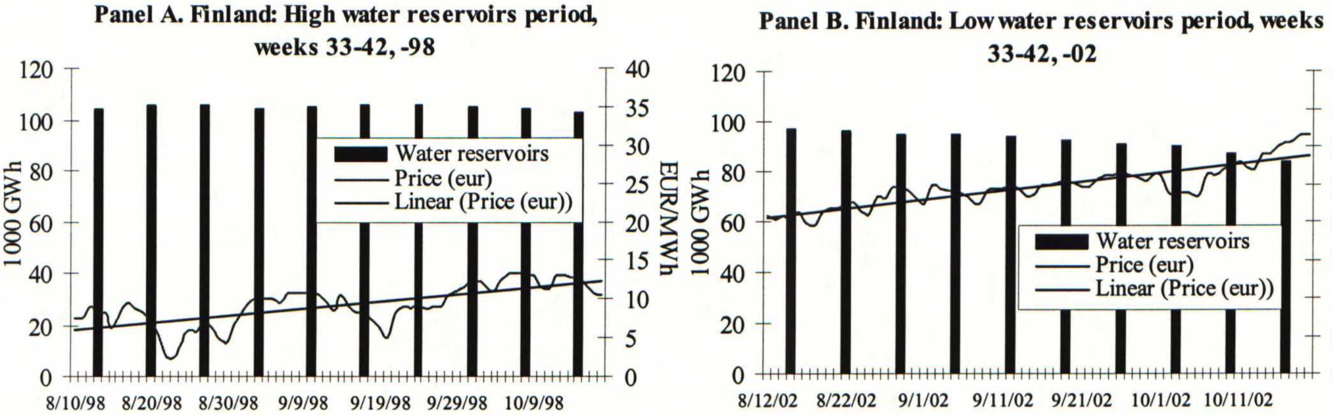

Figure 25 **Prices and water reservoirs in Finnish electricity markets in high and low water reservoir periods in the corresponding months in 1998 and 2002.**

In Panel A prices (EUR/MWh) and weekly water reservoir levels (1000 GWh) for a high-reservoir-period in weeks 33-42, 1998 are illustrated. In Panel B prices (EUR/MWh) and weekly water reservoir levels (1000 GWh) for a low-reservoir-period in weeks 33-42, 2002 are illustrated.

6.3 Tests for Market Efficiency

The first aggregate hypothesis states: "Finnish wholesale markets are more efficient than California wholesale markets". To test this hypothesis, I formed three sub-hypotheses, which covered the two forms of inefficiency typical for electricity markets – physical and trading efficiency. The tests for risk profiles and transmission constraints (and potential spatial market power) can be attributed to tests of physical inefficiency while the tests of arbitrage opportunities in California markets can indicate trading inefficiency. In the next sub-chapters the results of testing the hypotheses are summarized.

6.3.1 Risk Profiles

The first market efficiency hypothesis states that the risk profile of California electricity markets is higher than that of the Finnish market. Volatility and autocorrelation statistics tell something about the riskiness, predictability and finally the efficiency of the electricity markets. In Table 4 results of the volatility and autocorrelation tests are summarized. It first shows the absolute volatility, variance and autocorrelation figures for separate years of the both markets and then for the whole sample period. It also presents the test statistics for selected statistics for the purposes of comparative analysis.

Volatilities and Autocorrelations										
	California				Finland					California and Finland
	1998	1999	2000	*Whole sample*	1998	1999	2000	2001	*Whole sample*	*Test stats (Whole sample)*
COV	0.743	0.555	1.257	*1.670*	0.385	0.280	0.685	0.362	*0.526*	-
Hourly log-volat.	0.173	0.106	0.261	*0.121*	0.063	0.028	0.058	0.054	*0.051*	-
Hourly log-variance	0.030	0.011	0.068	*0.015*	0.004	0.001	0.003	0.003	*0.003*	*5.629**
Daily log-volatility	0.258	0.079	0.110	*0.185*	0.128	0.058	0.115	0.107	*0.102*	-
Daily log-variance	0.067	0.006	0.012	*0.034*	0.016	0.003	0.013	0.011	*0.010*	*3.268**
Autocorrelation										
1 lag				*0.946*					*0.893*	*41.577***
Average 24 lags				*0.751*					*0.479*	*53.245***
Average 168 lags				*0.625*					*0.361*	*41.876***
Average 720 lags				*0.546*					*0.313*	*34.008***

* F-test for independent samples, critical F-value (0.01 level) 1.032.

* z-test for autocorrelations of independent samples, critical z-value (0.01 level) 2.58.

Table 4 **Volatility and autocorrelation analysis for California PX day-ahead unconstrained and Nord Pool Finnish area prices.**

Coefficients of variation (COVs), hourly and daily log-volatilities and log-variances separately for 1998-2000 and the whole sample, and for 1998-2001 and the whole sample, for California PX day-ahead unconstrained and Nord Pool Finnish area prices, respectively. Autocorrelations with one hour, 24-hour- (1 day), 168-hour- (1 week) and 720-hour- (1 month) lags for California PX day-ahead unconstrained and Nord Pool Finnish area prices, respectively. Test statistics for the whole sample values – F-test statistics for hourly and daily log-variances (critical value 1.032 at 0.01 level) and z-test statistics for autocorrelations (critical value 2.58 at 0.01 level).

It clearly appears that the California markets incorporate much higher volatility than the Finnish markets, irrespective of the test statistic used. Namely, COVs as well as hourly and daily log-volatilities are persistently higher for the California sample than the Finnish one. F-tests also support the argument since the critical value 1.032 is far exceeded (the statistics are 5.629 and 3.268 for hourly and daily observations, respectively). The autocorrelation figures indicate an interesting fact – the California sample has far higher autocorrelations for all lags than the Finnish sample. z-correlation tests show a wide gap between the autocorrelation figures, since all the test statistics significantly exceed the critical value 2.58.

The price distributions in respective markets give important complementary information to the volatility analysis. Also, they are useful for checking the robustness of using average price figures over certain periods. Figures 26 and 27 present histograms of California and Finnish electricity prices with corresponding normal distributions drawn on the same scale.

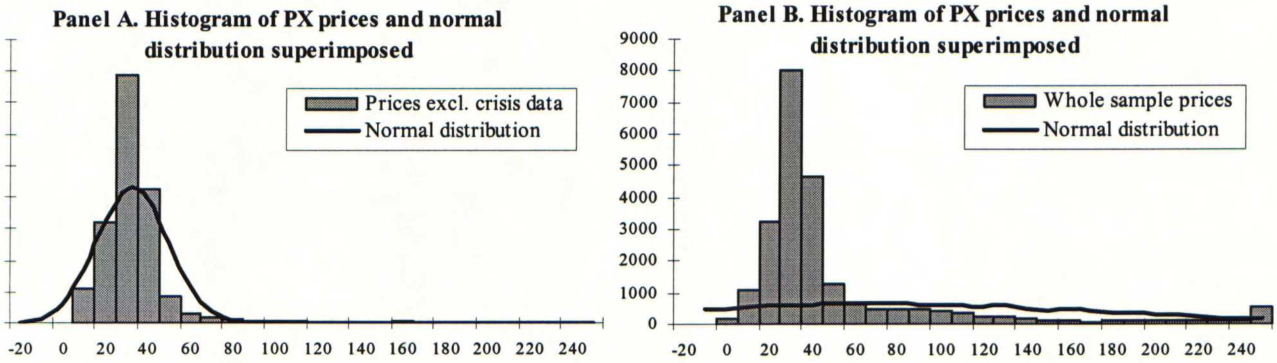

Figure 26 **Histograms of PX prices and normal distributions for the samples excluding and including the crisis period.**

Panel A presents the PX price distribution and normal distribution superimposed for the sample without the crisis period (April 1, 1998 - April 30, 2000). Panel B presents the PX price distribution and normal distribution superimposed for the whole sample period (April 1, 1998 - January 31, 2001).

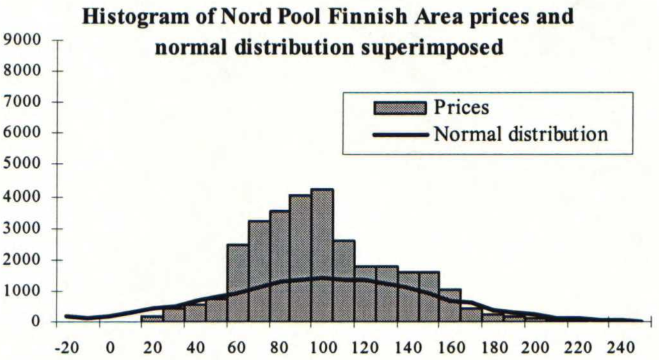

Figure 27 **Histogram of Nord Pool Finnish area prices and normal distribution.**

Nord Pool Finnish area price distribution and normal distribution superimposed for the sample period June 15, 1998 - October 15, 2002.

Undoubtedly, the California sample prices are much more widely dispersed and incorporate higher kurtosis than the Finnish sample prices. Therefore, the Finnish prices follow normal distribution much better than the California prices. Namely, the Finnish prices concentrate around the range €70-€100, while the California's equivalent range is much narrower, \$30-\$50. Also, the Finnish sample prices do not include such extreme quotes as the California prices (including the crisis period prices).

Figure 28 shows the price duration curves for California and Finnish electricity prices. It gives quite similar information than Figures 26 and 27. In particular, it once again highlights the differences between the California and Finnish price patterns. Since the California curves are much steeper the prices tend to be scattered over much wider area than the Finnish prices. Consequently, the higher consistency of Finnish prices implies that such statistics as average figures are probably more reliable when applied to the Finnish prices than the California prices. Also, these figures give further support to the previously found fact - the California prices incorporate much higher volatility than the Finnish prices.

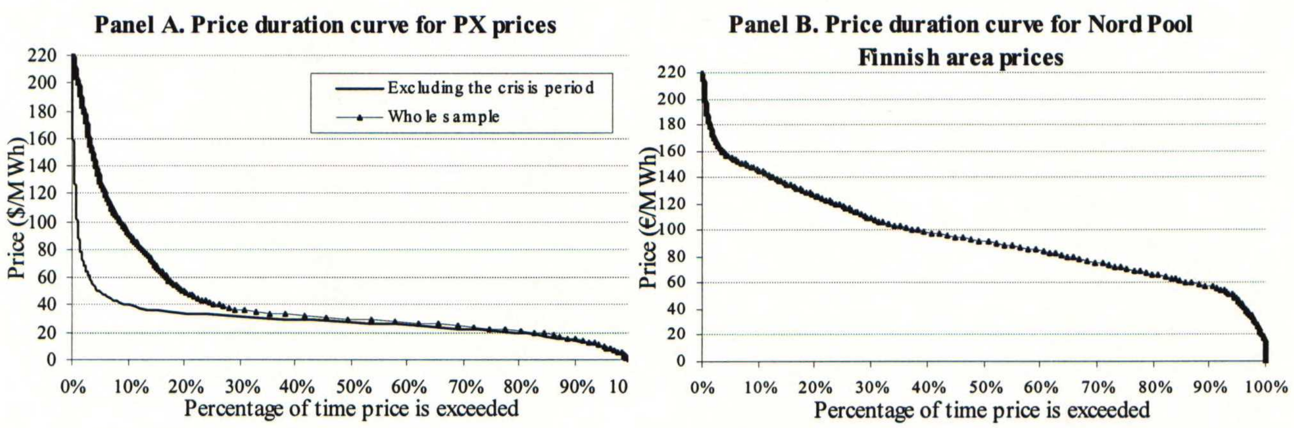

Figure 28 **Price duration curves for PX and Nord Pool Finnish area prices.**

Panel A shows price duration curves for the California PX sample (whole period April 1, 1998 - January 31, 2001) and sample without the crisis period prices (April 1, 1998 - April 30, 2000). Panel B shows price duration curve for the Finnish sample prices for June 15, 1998 - October 15, 2002.

As shown in Table 4, there is immense autocorrelation/persistency embedded in electricity prices in both markets. Particularly, the prices have a "good memory" in a sense that positive price increases tend to follow each other and vice versa for negative movements. Autocorrelation is often viewed as an unfavorable characteristic when modeling and testing hypotheses with statistical tools (I will come back to this problem when running regressions in chapter 6.3.2). However, autocorrelation can be a good thing when trading electricity since it can at its best help market participants to forecast and anticipate the near-term price levels and thus help handling uncertainty. Figures 29 and 30 depict the autocorrelations of prices in California PX and Nord Pool, also for squared prices, respectively.

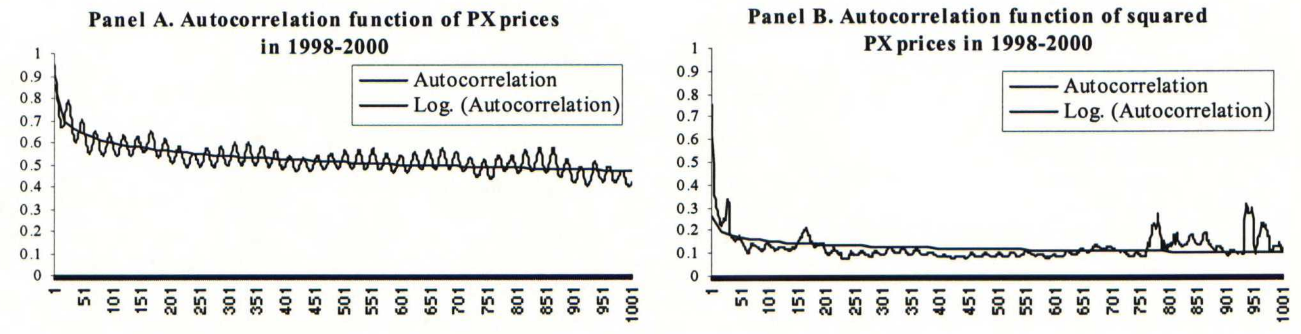

Figure 29 **Autocorrelation function of California PX prices and squared prices.**

Panel A. shows the autocorrelation function of PX prices from 1 through 1000 lags and a logarithmic approximation of the function. Panel B. shows the autocorrelation function of squared prices from 1 through 1000 lags and a logarithmic approximation of the function. Price data of both panels cover the time period April 1, 1998 - January 31, 2001.

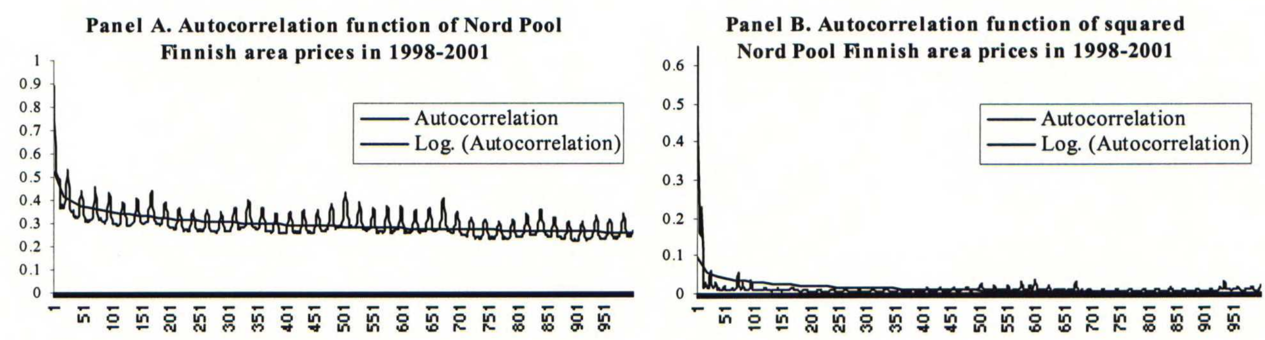

Figure 30 **Autocorrelation function of Nord Pool Finnish area prices and squared prices.**

Panel A. shows the autocorrelation function of Nord Pool Finnish area prices from 1 through 1000 lags and a logarithmic approximation of the function. Panel B. shows the autocorrelation function of squared prices from 1 through 1000 lags and a logarithmic approximation of the function. Price data of both panels cover the time period June 15, 1998 – October 15, 2002.

Figures 29 and 30 illustrate the numerical findings shown in Table 4. Specifically, the California sample appears to incorporate autocorrelation of squared prices even with 1000 lags, whereas the Finnish sample's autocorrelation of squared prices approaches zero already with 10 lags. Consequently, if taken together the findings of Table 4 and Figures 29 and 30, it is clear that the California prices have much higher autocorrelation embedded than the Finnish prices.

Price spikes in electricity markets are sometimes considered necessary for providing economic signals for agents who then promote efficient allocation of resources (Siddiqui, 2000). Nevertheless, these scarcity rents can be detrimental if the bids are not made at or near the marginal production costs (implying exercise of market power) or when they occur persistently more often than necessary for the firms to recover their fixed costs. In California markets, excessive price spikes were a considerable problem during the crisis from May 2000 through January 2001. The damage caused by these spikes induced the ISO to set price caps to help the utilities from going bankrupt and the consumers to incur higher electricity costs. Table 5 summarizes the results of the tests conducted to find out which of the markets incorporates higher price-spike-related uncertainly and riskiness.

Price Spike Analysis			
	California	Finland	Test statistic: t-test or ratio test
Average intra-day difference MAX-MIN ($s and €s)	58.47	9.29	-
Average intra-day difference MAX-AVERAGE, %	45.97%	45.46%	0.031*
Average intra-day max log price spike	0.197	0.102	8.777*
Percent of days (MAX-AVE)/AVE > 50%	29.41%	28.13%	0.711**
Percent of days (MAX-MIN)/AVE > 50%	72.82%	36.28%	18.482**
Percent of days max log price spike > 0.05	95.73%	54.24%	22.286**
Percent of hours log price spike > 0.05	13.51%	5.87%	30.962**
Percent of days max percentage price spike > +5%	99.32%	86.03%	11.678**
Percent of hours percentage price spike > +5%	25.05%	13.73%	34.036**

* Two-sample t-test assuming unequal variances, critical t-value (0.01 level) 2.58.

** Ratio test for two relative values, critical z-value (0.01 level) 2.58.

Table 5 **Price spike analysis for California PX day-ahead unconstrained and Nord Pool Finnish area prices.**

Average intra-day absolute difference between maximum and minimum and the percentage difference between maximum and average for California and Finnish prices. Average intra-day maximum logarithmic price spike (i.e. a logarithmic price increase between two consecutive hours) for both samples. Percent of days the intra-day maximum price exceeds the intra-day average price by more than 50% and the intra-day difference between maximum and minimum prices is higher than half of the intra-day average price. Percent of days the intra-day maximum logarithmic price spike exceeds 0.05 and percent of hours the logarithmic price spike exceeds 0.05. Percent of days the intra-day maximum percentage price spike (i.e. a percentage increase between two consecutive hours) exceeds 5% and percent of hours the percentage price spike exceeds 5%. Test statistics for the figures of the two markets – t-statistics (0.031 and 8.777) for the tests of differences in means and z-statistics for the tests of differences in ratios (i.e. a share of the whole population). The critical t- and z-values are 2.58 at a 0.01 level. The California and Finnish price samples cover the periods April 1, 1998 – January 31, 2001 and June 15, 1998 – October 15, 2002, respectively.

Table 5 suggests that, on average, the California sample prices spike higher and more frequently than the Finnish prices. Specifically, all the three first metrics measuring the magnitude of spikes show higher values for the California sample, even though the intra-day difference between maximum and average prices in California markets is not statistically higher than that in Finnish markets (t-value 0.031). All the metrics and ratio-test z-statistics measuring the frequency of price spikes point out that spikes occur on average more often in the California than the Finnish markets. Only the ratio measuring the days the intra-day maximum price exceeds the intra-day average price by more than 50 percent is not statistically higher in the California sample than the Finnish one (z-value 0.711).

6.3.2 Transmission Constraints and Spatial Market Power

In theory, market efficiency should make sure that all prices within a same interconnected area are equal. Therefore, there should be no need to adjust the unconstrained system price for congestion and bottlenecks in the transmission infrastructure, and thus derive area prices for those troubled areas. Also, the convergence of prices would indicate that no spatial market power was exercised. In practice, however, the gap between system and area prices exists. Therefore, instead of testing the existence of the gap per se, I will also test whether the gap is wider in the California sample than in the Finnish one.

Table 6 presents the results of testing the price convergence between system and area prices. In particular, the left part of the table shows the price impact hours (percentage of hours when the gap exists), percentage normal and absolute differences between system and area prices and standard deviation of the latter. Also, the correlation coefficients between the area and system price time series are reported. Further, the ability of system price to explain the area price alone and with a dummy-variable (which gets value 1 if the gap is positive and 0 in other cases) is tested with regressions. In the right part of the table the suitable test-statistics are presented. The ratio tests are used for testing the differences between price impact hours, t-tests for the differences in averages, F-tests for the differences in variances and correlation coefficient z-tests for the differences in correlations (see the critical values in the notes below the table).

System and Area Price Analysis					
	California		Finland	Test stats: CA (NP and SP) and FIN	
	NP15	SP15		NP15	SP15
Price impact hours, %	60.83%	60.87%	56.48%	10.357*	10.473*
Average percentage difference (system - area)	2.27%	-5.55%	5.97%	18.567**	57.328**
t-stat for average percentage difference within a market	-3.222	-10.386	-9.212	-	-
Average absolute percentage difference	4.96%	9.42%	9.62%	24.909**	1.038**
Standard deviation of absolute difference	0.211	0.218	0.23	1.192***	1.117***
Correlation between system and area price	0.906	0.887	0.880	15.372*	3.784*
Regression I: beta	0.777	0.705	0.752	-	-
Regression I: R Square	0.822	0.787	0.775	-	-
Regression II: beta (system)	0.790	0.720	1.026	-	-
Regression II: beta (dummy)	21.256	19.257	12.829	-	-
Regression II: R Square	0.828	0.798	0.787	-	-
Durbin Watson value for regressions****	0.286	0.289	0.285	-	-

* z-test for differences between ratios of price impact hours and correlations between system amd area prices. Critical z 2.58 at 0.01 level.

** t-test for differences in average percentage and absolute percentage differences between system and area prices. Critical t 2.58 at 0.01 level.

*** F-test for differences in variances. Critical F-value 1.03 at 0.01 level.

**** Critical values for all Durbin Watson tests are 1.65; 1.69.

Table 6 **Analysis of unconstrained system and area/zonal prices in California PX day-ahead and Nord Pool market.**

Percentage of price impact hours (i.e. hours when area price differs from system price), average percentage difference between system price and area price (system minus area price) in California and Finnish markets. t-statistic for differences in means of system and area prices within California and Finnish markets (the hypothesized difference is zero). Standard deviation of the absolute difference, and correlation coefficients between system and area prices. Beta value and R Square of a regression, in which the area price is dependent and the system price independent variable (Regression I). Beta values and R Square of a regression, in which area price is dependent and the system price and dummy-variable (which equals 1 when the gap between system and area prices is positive and 0 otherwise) independent variables (Regression II). Durbin Watson test statistics for the Regression 1. Test statistics for testing differences between the California NP15 and SP15, and Finnish figures – z-values for testing the differences between the ratios of price impact hours (critical z-value equals 2.58 at 0.01 level), t-values for testing differences between average percentage gaps between system and area prices (critical t-value equals 2.58 at 0.01 level), F-values for testing differences between variances/standard deviations (critical F-value equals 1.03 at 0.01 level), and z-values for testing differences between correlation coefficients (critical z-value equals 2.58 at 0.01 level). The California and Finnish price samples cover the periods April 1, 1998 – January 31, 2001 and June 15, 1998 – October 15, 2002, respectively.

Table 6 indicates four main points. First, the gaps between system and area prices in the California markets appear to be statistically significantly narrower than those in the Finnish markets. Namely, all of the test statistics, except that testing the difference between the average absolute gap in the Finnish markets and the California SP15 zone, are statistically significant (t-statistic for the SP15 zone is 1.038 and thus below the critical t-value of 2.58). Also, the t-value -3.222 for average percentage difference within the California market for the NP15 is significant at the lowest at 0.001 level, which indicates that the gap is fairly narrow between the system and NP15 area price.

Second, regression betas (all significantly different from zero) and R Squares indicate that system prices explain area prices quite well in both markets. Also, the sign of the gap appears to have significant explanatory power. Third, all the test statistics point out that the NP15 area price tends to converge more to the system price than the SP15 area price. Fourth, although the gaps are wider in the Finnish markets, ratio tests for the price impact hours show that they appear statistically significantly less often in Finland than those in the California markets.

Autocorrelation can impose serious problems on the right interpretation of the regression analysis results, since it causes positive correlation on the consecutive error terms (Lehtonen, T. 1998; 147). The Durbin Watson-statistics are presented in Table 6 for all regressions of Regression 1. Since the statistics for all three regressions fall below the critical lower d-value (1.65), the time series of differences in area and system prices incorporate positive autocorrelation. Therefore, the regression results should be considered with a slight caution.

6.3.3 Trading Efficiency and Arbitrage Opportunities

Market efficiency implies that if agents are risk neutral and transaction costs are absent then, at the time the PX day-ahead prices are determined, they should represent unbiased estimates of the ISO real-time imbalance prices (Borenstein et.al., 2001). If not efficient, there could be arbitrage opportunities in these market and the "inefficient" gaps between the two consequent markets could be identified and made profits of. Thus, by buying (selling short) power in a market with a lower (higher) price and selling (buying) it in a market with a higher (lower) price, agents could make (risky) arbitrage profits.

In an efficient market, a generator should expect, ex ante, to receive the same value from either setting aside capacity to provide power in the PX day-ahead market or reserving the same amount of capacity and providing it if called in the day-ahead A/S market (Earle et. al., 1999). This notion implies that the price in the PX day-ahead market should equal the price in the A/S market plus the real-time energy price (weighed with the probability of being called to provide the capacity). If this efficiency-condition does not prevail in the energy and capacity markets, market participants can shift away from the markets with a low price to those providing a better price. Eventually, the values should come down to equality.

I tested the existence of such above-mentioned inefficiency/arbitrage conditions with California data from April 1, 1998 through January 31, 2001 and the results are presented in Table 7[43]. The first two columns show the figures for the relationship of the PX and real-time ISO prices in NP15 and SP15 price zones. In the next columns the difference between the PX price and the value of A/S (day-ahead Replacement Reserves) with the probability-weighed[44] ISO real-time price is examined in NP15 and SP15 price zones. The value of providing capacity is calculated by adding the price paid for the service (A/S price) to the ISO real-time price multiplied by the ratio of energy demanded for available capacity (Earle et.al., 1999). In effect, the A/S price resembles the ISO's option to acquire the A/S capacity if needed, and the probability-weighed ISO real-time price equals the strike price weighed with the probability of being called.

Arbitrage Analysis: PX vs. ISO markets and PX vs. capacity markets				
	ISO(NP)-PX	ISO(SP)-PX	A/S(NP) - p * ISO(NP) - PX	A/S(SP) - p * ISO(SP) - PX
Average difference	0.711	-2.860	-48.56	-46.406
Stdev of difference	73.887	70.039	92.678	178.949
Correlation coefficient	0.645	0.626	0.528	0.169
t-test: p-value	0.011	0.000	0	0
Regression beta	0.492*	0.450*	0.258*	0.251*
Regression R Square	0.416	0.392	0.278	0.029
Durbin Watson value**	0.447	0.523	0.304	0.39

* Differ with 0.01 significance from zero

** Test for regressions: critical values for all Durbin Watson tests are 1.65; 1.69.

Table 7 **Arbitrage analysis of testing the relation between PX and ISO and PX and capacity (A/S) markets.**

Averages and standard deviations for the differences between the PX and ISO real-time prices, and the PX and A/S values (i.e. A/S price plus a probability weighed ISO real-time price) in NP15 and SP15 zones. Correlation coefficients and p-values for two-sample t-tests assuming unequal variances for the four sets of markets. Regression betas and R Squares for both markets and zones, when testing how well the PX prices explain the ISO prices and the A/S capacity values. Durbin Watson test statistics for the regression analyses. The price sample covers the period April 1, 1998 – January 31, 2001.

[43] Unfortunately, the same tests could not be conducted with the Finnish data, since there is no such markets and data available. Although Fingrid operates regulation down and up markets (quite equivalent to the A/S market), there is not such vast data set of that market. Therefore, the purpose of this analysis is merely to support the other findings.

[44] The weights are assumed to equal the hourly demand divided by the available capacity. The weight averages 4.7 %.

It appears from Table 7 that the PX day-ahead and ISO real-time imbalance markets are more in line with each other than the PX and A/S markets. Namely, the differences are on average smaller and less variable with the ISO and PX prices. Moreover, the p-value (0.011) of the t-test for the differences between the ISO and PX prices in NP15 indicates that the difference does not significantly differ from zero. In contrary, the other test statistics show no such evidence and thus incorporate larger differences. Regression analyses are conducted such that the PX price is set to explain the ISO price/capacity value. All the betas differ with a 0.01 significance from zero. The R Squares again imply that the PX and ISO prices tend to converge more than the PX price and capacity value.

The regression results in Table 7 are not surprising since there are several determinants (such as demand, supply and other general market conditions) moving especially the ISO and PX prices into a same direction. Therefore, the significance of the betas should be considered with caution. Additionally, the Durbin Watson test statistics, indicating autocorrelation for all regressions, further reduce the reliability of the regression results. As a whole, it appears that prices in the compared markets do not converge as much as they should in efficient markets and thus obvious arbitrage opportunities exist.

6.4 Analysis of Welfare Gains

As discussed before in this study, one of the most fundamental objectives of deregulating national or regional electricity markets is the expected improved welfare level brought by free markets and the related externalities. However, the improved overall welfare often comes at the expense of some parties' welfare. Consumers are expected to gain the most, as their power expenses are likely to go down (due to increased competition) and as better and more diverse services will emerge. Yet, the ex-monopolies (current competing free market actors with true market-based incentives to earn shareholder value) become exposed to uncertainty and stand to lose the most welfare in the process. In Figure 31 welfare of consumers in relation to producers/utilities in California and Finland is examined with wholesale prices. "Price threshold levels" help detecting the relative welfare gains/losses and transfers between consumers and producers.

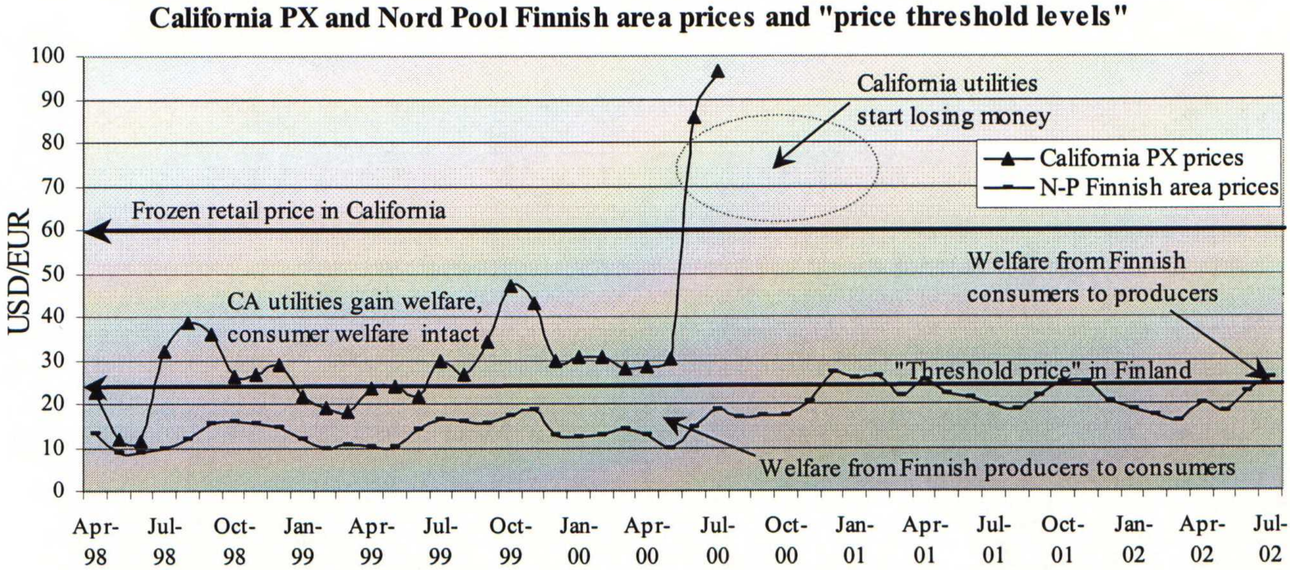

Figure 31 **Analysis of welfare gains and transfers in California and Finnish electricity markets.**

California PX prices from April 1998 through July 2000, and Nord Pool Finnish area prices from June 1998 through September 2002. Price threshold levels for both markets, i.e. the frozen retail rate of \$60/MWh and €25/MWh for California and Finnish prices, respectively.

Price threshold levels mean in this context the price levels in which a welfare transfer potentially occurs. California sample's threshold level equals the frozen retail rate determined in conjunction with the AB1890 (the deregulation bill) to ensure fast and full recovery of the utility stranded costs. Therefore, as long as the wholesale price stays below the frozen retail rate of approximately \$60/MWh, utilities as net purchasers gain welfare. Yet, consumers cannot benefit from the low prices since they are insulated from the price movements through the rate freeze. Figure 31 shows that during the period from April 1998 through May 2000 the California utilities were able to recoup their stranded costs and gained welfare in doing so. However, when the crisis hit in Summer 2000, wholesale prices suddenly jumped and never came down to their pre-crisis levels.

In effect, the crisis resulted in overall social welfare loss in California, since not only struggled the utilities but so will also the consumers, since the crisis expenses will eventually be channeled to them through higher electricity prices and increased taxes. Namely, the wholesale spot markets lost their efficiency once the PX ceased to exist in January 2001 and subsequently only high-priced long-term contracts were closed, mostly through the State. The economic consequences of these costly contracts are born by the Californian taxpayers and electricity consumers.

In the Finnish sample, the threshold price level averages €25/MWh. Practice shows that with spot prices above €25/MWh Finnish producers, as net sellers, start making return to the invested capital and thus gaining welfare (Mattila, 2002). Also, economically feasible capacity investments usually require prices in excess of the threshold price. If not sufficiently hedged, Finnish producers can potentially lose quite a lot if the wholesale price stays persistently below their marginal production costs of approximately €25/MWh. In that case, however, the end users usually gain relative welfare through lower power bills. In practice, the price decrease from levels prevailing before the reform and before Finland became a part of Nord Pool (e.g. in 1997 the EL-EX price averaged €19/MWh) has contributed especially to the competitiveness of Finnish energy-intensive industries through reduced costs of power (Mattila, 2002).

Big purchasers appear to have gained in relative terms more welfare than small consumers in Finland, since large industry users' sales prices have declined on average more than households' (based on statistics of Sähkömarkkinakeskus, 2000). This is a result of large consumers becoming eligible to enjoy the benefits (i.e. change suppliers) earlier than small consumers (Hynynen, 1999; 6). The small consumers' list prices have declined only after September 1998, when all consumers could start changing suppliers. As Figure 31 illustrates, the wholesale price has stayed most of the sample period below €25/MWh and, therefore, the welfare has probably channeled from the power producers mostly to the industry users and other big purchasers[45].

Table 8 presents average price movements in California and Finnish wholesale markets after trading commenced in the organized exchanges - in April 1, 1998 in the PX and in June 15, 1998 in the Nord Pool. First, nominal price changes are shown for years 1998-2000 for California and 1998-2002 for Finland. To eliminate seasonal characteristics of electricity, the results are presented in the upper panel for the same months in each year, i.e the one- and two-year changes are shown for April-averages for California markets and the one-, two-, three- and four-year changes are shown for June-

[45] At this point, it is worth pointing out that the discussion concentrates here merely on *sales prices* of electricity, not on total prices, which includes costs of transmission and distribution. Namely, the increases in power taxes of transmission prices have mitigated some the effects of deregulation.

averages for Finnish markets. To improve the information content of the price changes, the changes are adjusted for demand as well as natural gas and hydropower changes for California and Finnish samples, respectively. The lower panel shows the nominal and real (i.e. adjusted) price changes for year averages.

Nominal and real price changes

	California			Finland				
	Apr-99	Apr-00	Last sample month	Jun-99	Jun-00	Jun-01	Jun-02	Last sample month
Nominal change from 1-month-average-price	6.4%	17.8%	1295.1%	-6.6%	0.7%	112.5%	53.5%	94.9%
Demand-adjusted change from 1-month-average-price	2.2%	7.8%	1181.5%	-6.7%	-4.7%	103.1%	43.9%	60.3%
Resource-adjusted change from 1-month-average-price	11.5%	4.1%	451.5%	0.5%	9.6%	102.6%	62.3%	111.0%
Demand and resource adj. change from 1-mo-ave-price	7.1%	-4.7%	406.6%	0.4%	3.8%	93.7%	52.2%	73.5%
	1999	2000		1999	2000	2001	2002	
Nominal change from first-year-average-price	9.0%	324.5%		14.3%	24.5%	90.7%	71.0%	
Demand-adjusted change from 1-year-average-price	7.6%	300.4%		8.0%	15.9%	72.2%	56.2%	
Resource-adjusted change from 1-year-average-price	8.9%	184.7%		15.7%	30.2%	89.0%	68.6%	
Demand and resource adj. change from 1-yr-ave-price	7.6%	168.5%		9.3%	21.2%	70.7%	54.1%	

Table 8 **Nominal and real wholesale price changes for California PX and Nord Pool Finnish area prices.**

The upper panel shows the nominal, demand, resource, and demand and resource adjusted price changes from the first sample month averages to the subsequent years' same month averages and the last sample month averages for the California PX and Nord Pool Finnish area prices. First sample month is April 1998 for California sample and June 1998 for Finnish sample. The last sample months are January 2001 and August 2002 for California and Finnish samples, respectively. Resource adjustment means adjusting the power prices for movements in natural gas prices and water reservoirs in California and Finnish markets, respectively. The movements in resource levels are further weighed with the average yearly level of usage of the particular resource. The lower panel shows the nominal and demand, resource, and demand and resource adjusted price changes from the first sample year (1998 for both markets) averages to the subsequent year averages for the California PX and Nord Pool Finnish area prices.

The results shown in Table 8 are quite surprising. First, contrary to expectations, it turns out that the prices have not declined on average, after all. Instead, the price increases from the first to the last sample month averages are substantial for both samples. Second, the demand and resource movements appear to explain much of the price movements, especially the surge in the California prices during the crisis (see the "last sample month" price changes, i.e. changes in prices from April 1998 to January 2001 in California markets). Third, when viewing only the two-year price changes (thus excluding the crisis period in California), the adjusted price movements in California and Finnish markets do not seem to differ too radically from each other. Surprisingly, the Finnish prices have increased rather significantly from June 1998 to June 2001 and then come down in 2002 (yet to levels substantially above the 1998 levels). The yearly average price changes in the lower panel of Table 8 show more clearly the increasing trend in prices in both markets. As a whole, however, the California wholesale prices have increased much more than the Finnish prices.

6.5 Discussion of the Results

In this last chapter of the quantitative empirical part I will first discuss the results of the quantitative study in light of the previous findings in literature, discussed in chapter 5.2. Then, I will put together the results, discuss their implications for efficiency and welfare and assess how well the results are in line with the previously stated hypotheses.

Borenstein (1999) identifies exercise of market power in California markets and reports Cournot mark ups of 400%. Sulamaa (2001) and Kopsakangas-Savolainen (2002) have similar results from Finnish markets, but with mark-ups of only 23% and 114.9%, respectively. Exercise of horizontal market power can be a cause of the high Cournot mark-ups but potentially also the reason for excessive price volatility as well as large and frequent price spikes. I found statistically significantly higher price volatility and larger and more frequent price spikes in the California markets than the Finnish markets.

Arild and Halseth (2000) and Halseth (1998) discover convergence of zonal prices and increases in the Finnish area prices under free competition in the Nordic region. My results do not exactly support the first argument, since the difference between system and area prices was statistically significant, but support the latter one. Namely, the Finnish area prices were on average 5.97% higher than the system prices.

Borenstein et.al. (2001) find significant and persistent price differences between the day-ahead PX and ISO real-time imbalance prices. My results were similar in a sense that the difference was significant (at a 0.01 level) for the SP15 price zone. Yet, the p-value for the NP15 price zone was 0.011, showing significance only at a 0.05 level. My results from testing the difference between the day-ahead PX and A/S capacity value were in line with Earle et.al.'s (1999) findings, while differing from those of Bohn et.al. (1999). Namely, I found that the PX prices exceed significantly the A/S capacity value, meaning that market participants could at least in theory gain risky arbitrage profits from this obvious price discrepancy.

Figure 32 summarizes the main findings of the quantitative empirical study of California and Finnish markets. It also shows how the found characteristics can potentially affect the efficiency and welfare levels of the respective markets.

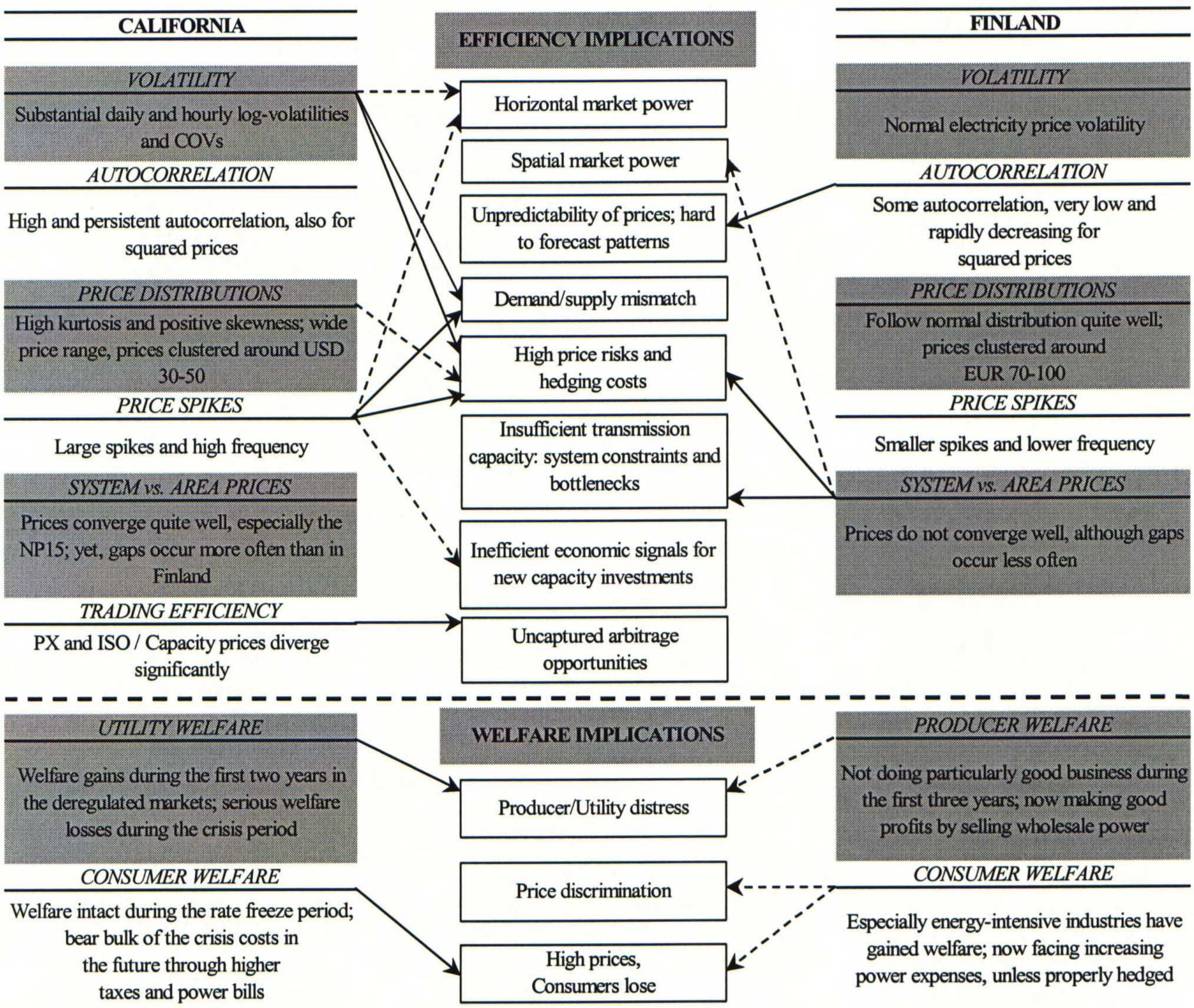

Figure 32 **Summary of results of the quantitative empirical study.**

The main findings from the California and Finnish wholesale electricity markets and their implications for market efficiency and welfare levels. The dotted arrows indicate 'potential' implications.

Five main causalities become evident from Figure 32. First, due to higher volatility and price spikes, the California markets evidence more potential for horizontal market power, higher price risks and mismatch of demand/supply than the Finnish markets. High volatility in California markets can be a symptom of immensely strict rules in the mandatory PX power pool. Namely, due to the restrictions to hedge positions and instructions to lower the level of long-term contracting, the California utilities held substantial un-hedged net short positions in the market. Also, the different power production resource portfolio in California could have contributed to higher volatility. Finally, due to the retail rate freeze, there was less demand elasticity in the California than the Finnish markets and thus potentially more volatility.

Second, significant and persistent price spikes in California could send inefficient economic signals for construction of new generation capacity. In particular, if unsustainable price spikes result in increased investments, there can be a risk of having uneconomic excess capacity once the prices normalize. The reverse is true if prices stay long below their "normal levels".

Third, due to the significant gaps between system and area prices, the Finnish transmission capacity appears fewer and less efficient than the California capacity. Also, the Finnish markets incorporate more transmission constraints and system bottlenecks as well as more potential for exercise of spatial market power than the California markets. Due to the gaps, Fingrid incurs higher capacity fees, which boost the transmission cost component of the retail electricity price. Also, since the derivatives contracts in Nord Pool are always based on the system price, while the crediting and debiting in the physical market base on the area price, gaps between system and area prices mean higher hedging costs and price risks for Finnish sellers and buyers.

Fourth, trading inefficiency in California markets, caused by gaps between the PX and ISO real-time and A/S prices, means un-captured arbitrage opportunities for market actors. The inefficient price formation can be due to the newness of the official power trading wholesale markets and the fact that market actors have not yet learned how the mechanisms and other actors work, and what factors move the prices. Also, it could be a case that transaction costs and risk aversion towards risky arbitrage strategies cause the gaps. Finally, the difference between production methods and fleet of day-ahead-traded energy and A/S-traded capacity can cause the differences between the PX prices and A/S capacity values.

Fifth, the overall welfare level has clearly declined in California as a result of deregulation, while in Finland welfare appears to have increased at least so far. Particularly, due to the utility bankruptcy and financial troubles as well as higher future electricity prices and taxes in California, welfare has fallen both through the utilities and consumers. These negative welfare effects can be results of poor overall deregulatory design in California markets. Specifically, the strict market rules and retail rate freeze enabled exercise of horizontal market power and other dubious market practices. Also, insufficient production capacity and extraordinary weather conditions could have contributed to the adverse welfare effects in California markets. In Finland, especially large consumers seem to have gained welfare so far but the price developments in 2002-2003 have obviously changed things as producers as net sellers have started earning better margins and retailers/sellers charging more from the consumers.

Table 9 presents the results of the quantitative empirical study in conjunction with the previously formed hypotheses. Also, it shows whether the results support the hypotheses or not.

ANALYSIS OF THE HYPOTHESES AND RESULTS OF THE STUDY	H supported (+) H not supported (-)
H1: FINNISH MARKETS ARE MORE EFFICIENT THAN CALIFORNIA MARKETS	
H1A: California markets have higher risk profile than Finnish markets	
(1) Volatility: Volatility in California markets significantly exceeds that in Finland	+
(2) Autocorrelation: Autocorrelation in California markets significantly exceeds that in Finland	-
(3) Price Spikes: Spikes are larged and occur more frequently in California markets	+
H1B: California markets incorporate more transmission constraints and potential spatial market power	
(1) System vs. area prices: Gaps between the prices are significantly narrower in California markets	-
H1C: California markets evidence trading inefficiency	
(1) Day-ahead vs. real time price: Significant gaps between the prices	+
(2) Day-ahead vs. capacity value: Significant gaps between the values	+
H2: CONSUMERS HAVE GAINED WELFARE; SPOT PRICES HAVE DECLINED ON AVERAGE	
- First post-reform years: Finnish consumers gained welfare, California consumers' welfare intact	+
- California consumers lost welfare after the crisis and Finnish consumers after price increases in 2002	-
- Wholesale spot prices have not declined as expected	-
H3: POWER PRODUCERS / UTILITIES HAVE LOST WELFARE	
- Producers in Finland have not gained significant welfare until recently	+ (-)
- Utilities in California gained welfare first but lost the gains and even more in the course of the crisis	+

Table 9 **Analysis of the hypotheses and results of the study.**

The efficiency and welfare hypotheses, results of the quantitative empirical analysis (presented below the hypotheses) and assessment on how well the results are in line with the hypotheses.

If taken together the results of Table 9, it appears that the first hypothesis (*H1)* gains on average more positive than negative support. Consequently, the Finnish markets seem more efficient than the California markets. Moreover, it seems that the second hypothesis (*H2)* does not get significant support. Although the Finnish consumers have gained welfare during the first post-reform years, the significant welfare losses of California consumers outweigh the gains in Finland. Finally, the third hypothesis (*H3)* gets support, as neither producers of Finland nor utilities of California have gained substantial welfare during the time after trading commenced, although the Finnish producers have done very well recently.

7 CONCLUSIONS

The study begun with Gordon's (2001; 351-352) words which outlined the antithesis of reforms in transportation and telephone sector. Accordingly, we have optimistic experiences from full deregulation in the transportation sector, and pessimistic experiences from the telephone sector (which have accrued from the regulator severely hindering evolution).

Gordon's (2001; 351-352) antithesis could easily be applied to the cases of California and Finnish electricity market reforms. In particular, the reformed markets in California had the same characteristics of strict regulation and governance as the telephone sector, while the Finnish reform was conducted much more extensively, without much regulatory intervention – like in the transportation sector. Although the comparative analysis of the special features of market reforms in California and Finland was the main theme of this study, the antithesis formed the fundamental impetus for this comparative study. Rest of the study discussed the implications of these reforms, based on the market characteristics and the conducted deregulatory processes.

In effect, the overall objective of this study was *two-dimensional*. First, the descriptive analysis focused on comparing the electricity market reforms in California and Finland through two framework approaches: heavy-handed and light-handed approaches. Second, the quantitative empirical analysis aimed at measuring and comparing the success of the deregulatory processes in California and Finland in terms of efficiency and welfare implications of the newly generated wholesale spot trading markets. Moreover, the study stressed the importance of the characteristics of pre-reform markets in providing impetuses and pre-requisites for the reforms. The objective was to provide a justified and robust answer to the question: "What are the economic foundations for the deregulatory processes chosen, the reforms' explicit features and the respective monetary outcomes in terms of efficiency and welfare gains?"

7.1 Discussion of the Main Themes and Findings

In a brief summary, the California pre-reform markets were characterized by tight regulation, which necessitated heavy-handed deregulation process, providing poor pre-conditions for functioning and robust wholesale and retail markets. In contrast, the indirect regulation in the Finnish pre-reform markets enabled light-handed reforms to fully deregulate the markets. The quantitative empirical analysis of the study indicated that the California wholesale spot markets were in effect less efficient than the Finnish markets. Moreover, the consumer as well as utility welfare level in California seemed to fall on average below those of the Finnish consumers and producers. Yet, it turned out that neither consumers nor utilities/producers in both markets gained significant welfare in the process. Next, the findings are presented in more detail.

In chapter 2 I concentrated on introducing the special features of the pre-reform markets and some inefficiency-related reasons to consider and conduct deregulation in respective electricity markets. Both of the pre-reform markets were constructed from *engineer's perspective* and thus incorporated such features as vertically integrated monopolies providing for all parts of the delivery chain as well as certain level of government or regulatory involvement on electricity supply. However, the markets differed from each other in various aspects. First, California had fewer and perhaps more powerful utility-monopolies enjoying more distinctive monopoly power and political leverage than the smaller regional monopolies in Finland. Also, duopoly in electric power transmission was an important characteristic in the Finnish markets. Second, the regulation in California was based on strict regulatory contracts, supervised by an active regulatory body, while the role of the regulator in Finland was basically reactive, powered by extensive government ownership. Third, the cost-plus electricity prices in California were derived with arbitrary accounting measures, providing level rate of return on investment, while in Finland the pricing was basically club-based, supported by loyalty, yardstick competition and negotiation.

California and Finland had different motives for deregulating the electricity markets, although the general objectives of welfare and innovation gains as well as efficiency improvements brought by deregulation gave the basic foundations for the reforms. In particular, excessive and uneconomic investments with lack of incentives to re-invest, cumulating stranded costs, false signals to investors and extensive government oversight in California were the main challengers of the old pre-reform structures. In Finland, such inefficiencies as duopoly power in electricity transmission, horizontal market power in distribution, uneconomic constraints in cross-border trades, price discrimination and cross-subsidization gave the main impetuses for reforms.

In chapter 3 I introduced and compared the deregulatory processes in California and Finland. I approached the issue from four core aspects: the role of regulatory authorities and public power, wholesale and retail unbundling, pricing and stimulation of competition in the new wholesale markets. First, I found out that most of the federal and state regulatory power enjoyed by the California authorities stayed at the pre-reform market levels after deregulation, although its distribution between different bodies altered somewhat. In Finland the oversight was distributed to two new authorities, which held a reactive rather than active control over operations. The wholesale level ownership unbundling in Finland, fully separating the power production and grid activities, was more extensive than the operational unbundling in California, where the utilities incurred huge stranded costs. Also, the retail level unbundling was conducted more fully in Finland than in California, because the retail rate regulation hindered competition in California. California set tight rules for trading wholesale electricity in the mandatory new official exchange, whereas the wholesale trades in Finland in the new wholesale market, Nord Pool, remained totally optional. All in all, the California deregulation was conducted heavy-handedly in a sense that heavy rules and arbitrary controls prevailed in the supposedly free deregulated power markets. In contrary, the Finnish reform resembled a light-handed approach, since the market actors were mostly allowed to operate freely without high regulatory or political ties.

In chapter 4 I introduced the physical features of electricity and some special characteristics of electricity trading, with special emphasis on volatility as well as physical and trading efficiency. Also, I discussed the welfare gains and transfers in deregulated power markets. Due to the physics of electricity, the same characteristics applied for the both markets and, therefore, there was lesser comparative analysis involved.

In chapter 5 I laid the groundwork for the analysis of the wholesale markets. First, I discussed the wholesale mechanisms in both markets and compared them to each other. The special emphasis was on the price formation and motives of having several prices in one market. It turned out that the both markets had fairly similar mechanisms for organizing the necessary balancing and grid operations as well as the hourly price formation. However, the California markets seemed to have somewhat more complicated system, which called for more supervision and administrative control. Second, I summarized the most relevant findings of existing literature and introduced the sample data and methodology. Finally, I introduced the hypotheses and some theoretical background supporting them. The first main hypothesis, stating that the Finnish wholesale markets are more efficient than the California markets, comprises three sub-hypotheses: risk profile, transmission constraints and spatial market power and trading efficiency hypotheses. The second and third main hypotheses argue that consumers have gained welfare and producers/utilities have lost welfare, respectively. Therefore, they handle the welfare gains in general level and thus are not comparative in nature. I tested these three main hypotheses in chapter 6 through the sub-hypotheses and derived conclusions of the results from the findings based on the sub-hypotheses.

In chapter 6 I presented the results of the quantitative empirical study, backed by descriptive statistics and illustrations of how demand and resource conditions affect electricity prices. It turned out that the price level is on average considerably higher and the price range (between maximum and minimum prices) much wider in the California markets than in the Finnish markets. Also, seasonal patterns in electricity prices as well as the impacts of demand and main resource conditions on prices are obvious and identifiable in both markets.

I measured volatilities and autocorrelations as well as the frequency and magnitude of price spikes when testing the risk profiles of markets in California and Finland. It turned out that the California markets incorporate much higher volatility, autocorrelation and price spikes (which also occur more often) than the Finnish markets. Consequently, the first sub-hypothesis of efficiency is accepted – the risk profile of the California markets appears higher than that in the Finnish markets. The tests for transmission constraints and potential spatial market power, conducted by measuring the gaps between system and area prices, implied that the Finnish markets incorporate statistically significantly wider gaps. Therefore, the second sub-hypothesis of efficiency is rejected – Finnish electricity markets incorporate more evidence of transmission constraints and spatial market power than California markets. The third sub-hypothesis of efficiency gains strong support – there appears to be significant trading inefficiency in California real-time and capacity markets.

I analyzed the welfare implications of deregulation graphically by comparing the price levels with the price threshold levels and numerically by calculating nominal as well as demand- and resource-adjusted price changes. It turned out that the consumers in Finland gained relative welfare first after deregulation, but the situation appeared to reverse at some point in 2001-2002 when the producers started to profit at the expense of consumers. Since the spot prices in Finland have not decreased in real terms as expected, consumer welfare has not increased accordingly, based on prices alone. In California, consumer welfare level stayed intact at first after deregulation due to the rate freeze. Yet, the crisis cut the welfare and the trend goes on in the future as consumers continue to indirectly pay the crisis expenses. The utilities on the other hand gained some welfare first when profiting from the wide gap between the frozen retail price and low wholesale prices. However, when the crisis hit, all the utilities wound up in financial distress.

All in all, the quantitative empirical analysis indicated the following. Since the efficiency hypothesis gains on average more positive than negative support, the Finnish markets seem more efficient than the California markets. It appears that the second hypothesis is (lightly) rejected - consumers in both markets have not gained welfare quite as expected, although the Finnish consumers have been far better off than the California consumers. However, the third hypothesis is accepted, since neither producers of Finland nor utilities of California have gained substantial cumulative welfare during the entire time after trading commenced.

7.2 Current Stage and Future of California and Finnish Electricity Markets

7.2.1 California Electricity Markets

California electric power market is now in a transitional stage - most of the policy changes put in place have been annulled and replaced with new regulations. Most importantly, due to the crisis, the state government has stepped in and taken a major role in the power markets as a primary purchaser of electricity in the ISO-controlled area normally served by now insolvent or bankrupt utilities. Given recent developments and hardships in California power markets, various opportunities and niche markets for energy technologies have emerged. Granted, the market still lacks consumer choice and free competition in both wholesale and retail levels. Still, there are markets for companies involved in building efficient and clean supply capacity, management and optimization software to improve grid operations and resource technologies able to contribute to increased self-sufficiency and more diversified energy resource portfolio in California (Haljala, 2002; 3).

The crisis and unsuccessful deregulatory process have left operational and especially regulatory uncertainties in the California power markets - investments in the current market are clearly affected by the prevailing institutional chaos and financial instability. Nevertheless, a lot of work has been done to restore regulatory certainty, stability and healthy competition in California electricity markets - both in federal and state level. Yet, there is a distinct need to do more to make California wholesale power markets work better and increase the state cooperation with both the federal government and other western states. At the end, transparency and healthy signals in the market cannot be achieved before decisive long-term planning and setting of standards in new generation, transmission and demand management issues have been conducted (Haljala, 2002; 94).

7.2.2 Finnish Electricity Markets

The current stage in the Finnish electricity markets is far different than that in the California markets, although the recent developments in Nord Pool have indicated close to similar problems in Finland as in California during the crisis. Basically, there are three main factors, which make the current situation and the future in the Finnish markets especially interesting and topical – the soaring wholesale spot prices in Nord Pool, the Parliament's ratification to construct the fifth nuclear power plant and the further liberalization developments.

First, due to the record scarce rainfalls in 2002 and low temperatures in late 2002 in the Nordic region, the Nord Pool system spot price has recently skyrocketed to unprecedented levels (averaging €101/MWh in January 7, 2003). According to Taisto Turunen, the head of energy department at the MTI, Finland could face electricity shortages and savings programs in early 2003 unless freezing weather starts easing during the peak demand periods. However, retail price increases have remained surprisingly moderate, averaging only six percent this year (which makes the retail price to account for only one third of today's wholesale price) (Jouslehto, M., 2002; 6). Therefore, consumers have not at least so far suffered much from price increases. Instead, producers (net sellers to Nord Pool) have been the biggest winners while the retailers/sellers have made considerable losses.

Consequent to the skyrocketing prices, some Finnish producers and utilities have come to criticize the high dependency of hydropower in the Nordic region and even the trading rules of Nord Pool. Particularly, they argue that the producers controlling hydro reserves hold monopolistic power in determining the price for all the Nordic power, irrespective of production method and source. It is seen unreasonable that even though the production costs of natural gas, coal or nuclear power have not changed, the end-product price fluctuates totally based on Norwegian rainfalls (Lunden, 2003a; 5). Moreover, certain energy-intensive companies have started to keep idle some of their capacity due to high prices. In effect, they are replacing some of their core business activities with more profitable utility activities. Companies having ownership stakes at PVO or TVO are not so much affected since they can procure the power at production cost (Lunden, 2003b; 4).

Second, year 2002 has been significant also due to the Finnish Parliament ratification to accept construction of the fifth nuclear power plant. The decision effectively changed the overall energy policy in Finland and it is important in increasing Finland's self-sufficiency in power production, enhancing the competitiveness of energy-intensive industries and cutting price spikes. However, the decision to build the 10 TWh nuclear power facility to the 400 TWh power market had hardly any effects on the Nord Pool system prices in May 24, 2002. However, the new facility has a potential to decrease the gaps between the system and area prices (Pantsu, 2002a; 4).

Third, the liberalization of Finnish electricity markets is still in process – the Electricity Market Act is to be revised in 2004. The revision will compel utilities with over 130 GWh distribution capacity to separate power distribution and sales by incorporating the grid activities to a totally separate company. While incurring high costs especially to small utilities and increasing M&A activity and size of large actors (Vattenfall and Fortum), the revision is expected to increase competition and cut cross-subsidizing (Pantsu, 2002b; 4).

Of course, the future of Finnish electricity markets is highly uncertain. However, it is likely that should the electricity prices remain high, more production capacity is build in the Nordic countries. This could help keeping price spikes in control and putting the markets in better balance. Also, the immense reliability on hydropower will most likely to be reduced by focusing on alternative power production sources. High prices have potential of undermining the success of deregulation by decreasing retail competition. Since utilities would have to buy the power sold to new customers with high prices from Nord Pool, they are no longer willing to serve customers outside their own service areas, or they will rather sell the extra power to the pool. Therefore, the fact that the number of sellers willing to serve outside customers with discount prices has declined, has made it useless for consumers to compare suppliers and their pricing practices to support decisions to switch them (Lassila, 2002; D1). Consequent to the price surge, the discount prices are in effect on average higher than the list prices available to the customers of the utilities' own service areas.

In any case, once the latest fixed-price long-term power contracts expire in 2005, Nord Pool will become the only market for practically all power produced in Finland and procured into Finland. This can result in higher volatility and uncertainty as well as more price shocks. However, it can also mean lower prices, due to more transparent price formation and efficiency, as well as more optimal distribution of welfare. Yet, higher use of hedging instruments, successful completion of the deregulation process and increased use of domestic resources are necessary preconditions for future success in Finnish electricity markets.

7.3 Further Research Possibilities

The California electricity markets have been widely and fairly intensively researched topic during this century. The crisis in 2000-2001 raised questions on which factors contributed the soaring prices, shortages and eventual institutional and regulatory chaos. The potential exercise of market power was also extensively researched. In contrary, the Finnish electricity markets have not drawn nearly as much attention as a research topic as the California markets, although Finland was one of the first countries in Europe to deregulate its domestic markets.

Due to the recent developments in Nord Pool, Finnish power markets have (among other Nordic markets) become especially interesting research topic. Namely, it would be quite interesting to know, which were the causes and implications of the power crisis in the Nordic region in 2002-2003. First, it could be investigated which specific factors contributed to the exceptionally high prices in Nord Pool, and why they came into effect particularly at that time. Second, it could be worth exploring, which parties gained the most during the price shocks and whether the price movements could have been precisely forecasted and made profits from those forecasts. Third, it would be interesting to study how the price developments affected the transmission capacity constraints (gap between area and system prices) and short-term competition in the markets (gap between market price and MPC). Finally, it could be explored how the price surge affected the construction of new generation capacity and the choice of the generation technique.

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